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A PRELIMINARY STUDY OF THE TASTE AND ODOR PROBLEMS IN GRAND LAKE, OHIO AND THE WABASH RIVERS, INDIANA

Max A. Anderson, et al

Federal Water Pollution Control Administration
Evansville, Indiana

October 1969

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By
Max A. Anderson
Aquatic Biologist
And
James H. Adams, Jr.
Microbiologist

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16. Abstracts The purpose of this study is to determine to what extent algal nuisance conditions might be responsible for problems in the Grand Lake area. Water samples were collected in Grand Lake, in water that is highly turbid and with benthic deposits containing a substantial amount of algal detritus. Results of the application of the Wabash River Stream Quality Model using the data gathered include algal, nutrient, physical, chemical and stream flow information.

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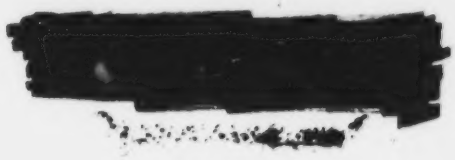
A Preliminary Study of the Taste and Odor Problems In Grand Lake, Ohio and the Wabash River, Indiana



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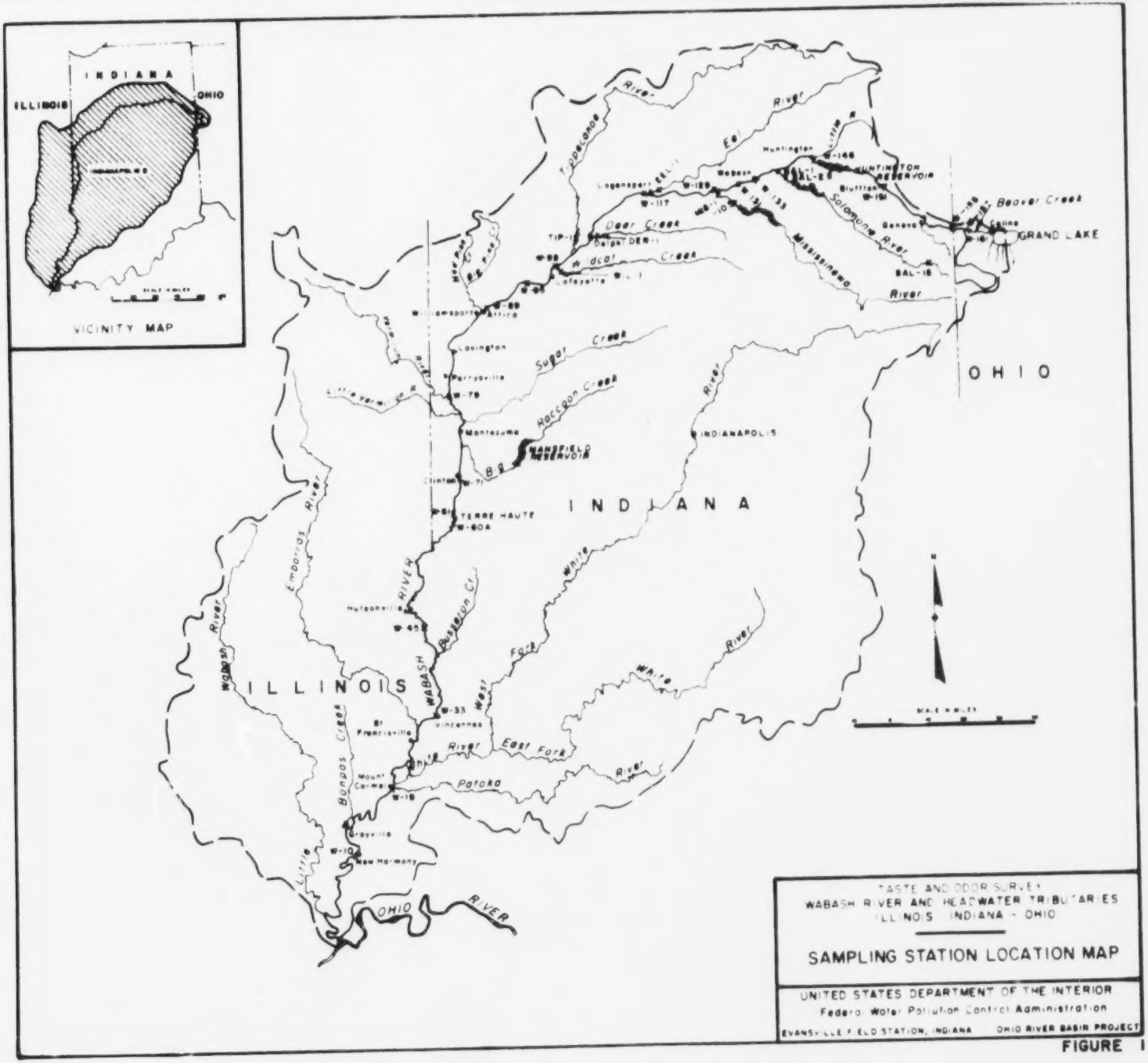


TASTE AND ODOR SURVEY
WABASH RIVER AND HEADWATER TRIBUTARIES
ILLINOIS - INDIANA - OHIO

SAMPLING STATION LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA — OHIO RIVER BASIN PROJECT

FIGURE 1

I. INTRODUCTION

GENERAL

To be safe and palatable, drinking water must be without taste or odor and free from harmful microorganisms, chemical constituents and radioactive substances. To accomplish this goal, waterworks officials as well as public health authorities are constantly striving to improve water treatment techniques.

Tastes and odors are probably the most complex of all problems in the treatment of a water supply. The causes are many and may be either natural or manmade. Natural causes include algae, decaying vegetation, slimes, molds, micro and macro-invertebrates, etc.; while sewage, industrail wastes and accidental spills represent manmade causes.

Of the natural causes, algae along with actinomycetes and decaying vegetation are the most frequent offenders. In addition, many invertebrate organisms impart objectionable materials to the water during the normal course of completing their life cycle; others generate odorous compounds in the process of decomposition.

Among the many organic and industrial wastes frequently causing tastes and odors are materials that belong to the mercapton group. Often, as little as one part per billion of these compounds can be detected (tasted) in drinking water.

PURPOSE AND SCOPE

The purpose and scope of this study is to determine to what extent algae and actinomycetes might be responsible for producing tastes and odors in the Wabash River, and in Grand Lake in Western Ohio, a highly

enriched lake which contributes a substantial amount of algae, actinomycetes and nutrients to the upper reaches of the Wabash River during periods of high lake stages.

This study is based upon a survey conducted by the Biology Unit, with laboratory assistance from the Microbiology and Chemistry Units of the Lower Ohio Basin Office. The data gathered include algal, actinomycete, physical, chemical and streamflow information. Similar data were also gathered from the major tributaries to the Wabash River, and from eight tomato cannery lagoons in the vicinity of the Wabash River.

Forty sampling sites were established at key positions: (1) in Grand Lake; (2) in the Wabash River from Wabash, Ohio to New Harmony, Indiana; (3) at locations near the mouths of the major tributaries; and (4) in selected cannery lagoons (Table 1). All sampling, except for actinomycetes, began on November 16, 1967 and continued at 4 to 6 week intervals thereafter through mid-June 1968 in the Wabash River and through mid-November 1968 in Grand Lake. Actinomycete sampling began February 20, 1968 and continued through mid-June following the same timetable.

II. SUMMARY

1. Beginning November 16, 1967 and continuing through June 15, 1968, a survey was undertaken to determine possible causes of acute springtime tastes and odors detected in the finished water supply at Celina, Ohio, Huntington, Indiana and Mt. Carmel, Illinois. The city of Terre Haute, Indiana experienced similar taste and odor problems prior to converting to a groundwater source in 1967.
2. Algal, actinomycete and chemical data were collected from Grand Lake and the Wabash River. The populations of algae and actinomycetes were studied to determine population trends and species composition, since certain species belonging to both groups are known to produce taste and odors. Chemistry data were gathered to determine the amount of nutrients present. These included nitrate-nitrogen, ammonia nitrogen, total Kjeldahl nitrogen, total phosphorus, total soluble phosphorus, and soluble orthophosphate-phosphorus. Also included were suspended volatile solids, dissolved oxygen, water temperature, pH, conductivity and turbidity.
3. The cities of Huntington, Indiana and Mt. Carmel, Illinois receive their raw water from the Wabash River. The city of Celina, Ohio gets its water from Grand Lake. Algae and actinomycetes were always present in both of these sources, but in varying degrees of concentration depending upon flow conditions, changes in water temperature, etc.
4. The algal population in Grand Lake ranged from 58,900 to 382,300 algae per ml, with little variability in the species composition. The greatest concentration occurred in June 1968. The actinomycetes

ranged from 40 to 29,600/ml, with the highest count being recorded on February 20, 1968. No actinomycetes samples were collected prior to February 20.

5. The blue-green alga Schizothrix calcicola was the most predominant form in Grand Lake and comprised approximately 72 percent of the lake's algal population.
6. Schizothrix calcicola was found to be present in abundance in the upper reaches of the Wabash River only during high water periods when a substantial amount of water was flowing from Grand Lake.
7. Actinomycetes in Grand Lake and in the Wabash River were highest during periods of heavy rain and flooding. The highest count for the Wabash River occurred on February 20, 1968 at Peru, Indiana where 60,400/ml actinomycetes were recorded. The second highest count was at station 95 downstream from Lafayette, Indiana. Here 59,200/ml actinomycetes were recorded for the same period.
8. The diatom Cyclotella was the most predominant alga in the Wabash River during the course of the study. The average count for all stations for the fall and spring months (November, April, May and June) was 16,400/ml and for the winter months (December through March), the average count was 6,520/ml.
9. Threshold odor determinations were run on a monthly basis from February to June 1968. Samples were collected from Grand Lake and from the Wabash River at Wabash, Indiana; Attica, Indiana; Terre Haute, Indiana; and Mt. Carmel, Illinois. Threshold odors ranged from 100 to 3200 in Grand Lake and from 4 to 24 in the Wabash River.

10. The most pronounced increase in the algal population in the Wabash River during the study occurred at an expected "bloom" period between April and June. The one exception to this was at Mt. Carmel, Illinois, where the algal population was very low during these months. This was probably due to the fact that intense rain and high turbidity occurred locally, greatly inhibiting algal growth.

11. Nutrients in Grand Lake and in the Wabash River were consistently high throughout the survey. In Grand Lake the nitrate nitrogen averaged 0.90 mg/l and the total phosphorus averaged 0.22 mg/l. In the Wabash River, the average nitrate nitrogen for all stations ranged from 2.3 to 3.45 mg/l and the average total phosphorus ranged from 0.17 to 0.43 mg/l. Soluble orthophosphate phorphorus in Grand Lake averaged 0.127 mg/l, and in the Wabash River ranged from an average for all stations of 0.066 to 0.276 mg/l.

12. The dissolved oxygen in the Wabash River was substantially high, reaching supersaturation concentrations during May and June. The dissolved oxygen concentration in Grand Lake was also high but never supersaturated.

13. To learn to what extent lagoons might contribute to the taste and odor problem, eight cannery lagoons which empty directly into the Wabash River or into its tributaries were sampled to determine the nutrient content, algal composition and actinomycetes population.

14. Sampling was conducted near the mouths of the major tributaries to the Wabash River. They are the Salamonie, Tippecanoe, Eel and Mississinewa Rivers, and Wildcat and Deer Creeks.

III CONCLUSIONS

1. Grand Lake - Celina, Ohio. Based upon the findings of this study, it is concluded that Celina, Ohio's taste and odor problem is due largely to taste and odor-causing algae and actinomycetes. Among the algae most likely responsible are Aphanizomenon (blue-green), Anacystis (blue-green), Synedra (diatom) and Scenedesmus (green). In addition, the filamentous blue-green alga Schizothrix calcicola is present in extremely large numbers (comprising approximately 72 percent of the total algae population), and although the evidence to define it as a taste and odor producer is presently lacking it cannot be overlooked as a likely contributor to Celina's taste and odor problem. The actinomycetes contributed most to the problem during February and March when the lake level was highest resulting from intense rain and snowmelt. At this time actinomycetes were recorded in excess of 29,000 per ml.

   Huntington, Indiana. Tastes and odors at Huntington during the month of February 1968 were a result of algae and actinomycetes entering the Wabash River from Grand Lake. Tastes and odors detected during May and June 1968 came primarily from the river's algal population, which was predominately Cyclotella. The actinomycetes during these latter two months reached a high of only 320/ml and were therefore considered only minor contributors to Huntington's taste and odor problem.

   Terre Haute, Indiana. The actinomycete population in the vicinity of Terre Haute was highest during February, May and June of 1968, when 14,800, 13,200 and 2,800/ml respectively were recorded, while the algal

population (principally the diatom Cyclotella) was highest in May and June with 43,180 and 32,270/ml respectively. In view of these relatively high numbers, it is concluded that both actinomycetes and algae are responsible for much of Terre Haute's springtime taste and odor problem.

Mt. Carmel, Illinois. Actinomycetes were largely responsible for Mt. Carmel's 1968 springtime taste and odor problem, as evidenced by two peak periods which occurred in February and May where counts were 22,400 and 19,200 respectively. Algae populations during these same periods were low and were less significant to the overall problem at Mt. Carmel. No doubt, other factors such as decaying organic matter, and industrial effluents from upstream sources also contributed.

2. The actinomycetes population in the cannery lagoons averaged 240/ml and contributed only slightly to the taste and odor problem in the Wabash River.

3. Although a dense population of the green alga Chlorella and the green flagellate Chlamydomonas was present in nearly all of the cannery lagoons, it is doubtful that these algae were very influential in causing tastes and odors in the Wabash River since their numbers in that part of the river receiving cannery wastes were low.

4. Actinomycetes flushed from pools and soils on the floodplain along with scouring bottom-muds combine to comprise the bulk of the Wabash River's actinomycetes population. The number of actinomycetes present in the river depends largely upon the amount of flooding that occurs.

IV. STUDY AREA DESCRIPTION

GRAND LAKE

Grand Lake, located in Mercer County, Ohio was constructed in 1845 to supply water for the former Miami River and Erie Canal system. It is a shallow warm water lake encompassing 17,500 acres and is surrounded by a drainage area of approximately 93 square miles of primarily agricultural land. The lake is somewhat rectangular in shape with its most distant points lying in an east-west direction. The lake has an average depth of 8-9 feet, with the shallowest area near the center and deeper water at each end.

Grand Lake is a multi-purpose lake providing water for domestic, recreational and industrial needs. It is fed by four major tributaries that enter from the south and west. The lake has outlets from two spillways: The spillway on the west shore discharges (during high water) to Beaver Creek, a tributary to the Wabash River; the spillway on the east shore supplies water to the St. Marys River, a tributary to the Maumee River.

WABASH RIVER

The Wabash River originates in Mercer County, Ohio some 15 miles east of the Indiana-Ohio State line. Flowing in a northwesterly direction for nearly 65 miles, the river gradually turns toward the southwest and then to the south until it joins the Ohio River in the vicinity of Mt. Vernon, Indiana. Of the many tributaries entering the Wabash River along its 500 mile course, nine are of primary importance. They are the Salamonie,

the Mississinewa, the Eel, the Tippecanoe, the Vermilion, the Embarras, the White, the Patoka, and the Little Wabash Rivers. Together, they constitute the greater majority of the Wabash River Basin, which drains an area of 33,100 square miles and includes about 67% of Indiana, about 17% of Illinois, and some 300 square miles of Ohio.

V DISCUSSION

GRAND LAKE STUDY

Background of Grand Lake Study

The city of Celina, Ohio is located on the northwest corner of Grand Lake. Prior to 1952, the city's raw water came from four wells. Because of the poor quality of water in these wells (2 mg/l iron), a study was made to locate additional water supplies. As a result of this study, it was recommended that the city use Grand Lake for its new water source. To provide the quality of water needed, the city constructed a 1.5 mgd water softening plant of the lime-soda-ash type. The new treatment plant was put into operation in the spring of 1952.

By 1960, objectionable tastes and odors from this new water source had become a serious problem. Various treatment methods were employed to combat the problem, with varying degrees of success; on many occasions the taste and odor intensities were greater than the capabilities of the treatment method. By the fall of 1962, the tastes and odors in the finished water were so objectionable that the city retained a consulting engineer to determine ways of correcting the problem.

Following a one-year study, the consulting engineer concluded that algae were the primary contributors to Celina's taste and odor problem with a possibility that actinomycetes were also contributing. To alleviate the problem, according to the consulting engineer, a method first had to be devised to combat or greatly reduce the algal population. Chemical treatment, the use of holding basins, or both, was recommended.

Approach to Grand Lake Study

Grand Lake is located near the headwaters of the Wabash River. In the past the lake has supplied water to the river at the rate of 250 to 300 cfs during periods of high water when flooding occurs. Because the city of Celina experiences objectionable tastes in its drinking water throughout most of the year, the lake was considered to be a prime source of taste and odor problems in the Upper Wabash River. A sampling station was established in the lake at the west spillway. Stations were also established near the mouth of Clearwater, Beaver and Chickasaw Creeks, the major tributaries to Grand Lake.

In order to maintain a continued surveillance of the algal population in Grand Lake after the study concluded in June 1968, arrangements were made with the personnel at the Celina, Ohio Water Treatment Plant to send water samples from the lake to the Evansville Office on a monthly basis during July through November 1968.

A survey of the data showed that the algal population in Grand Lake over a period of one year ranged from 58,900 to 382,000/ml, with little variability in species composition. The predominant form was the blue-green alga Schizothrix calcicola which comprised approximately 72 percent of the lake's total algae population. Of the known taste and odor-producing algae, Aphanizomenon (blue-green), Anacystis (blue-green), Scenedesmus (green), and Synedra (diatom) were the most abundant.

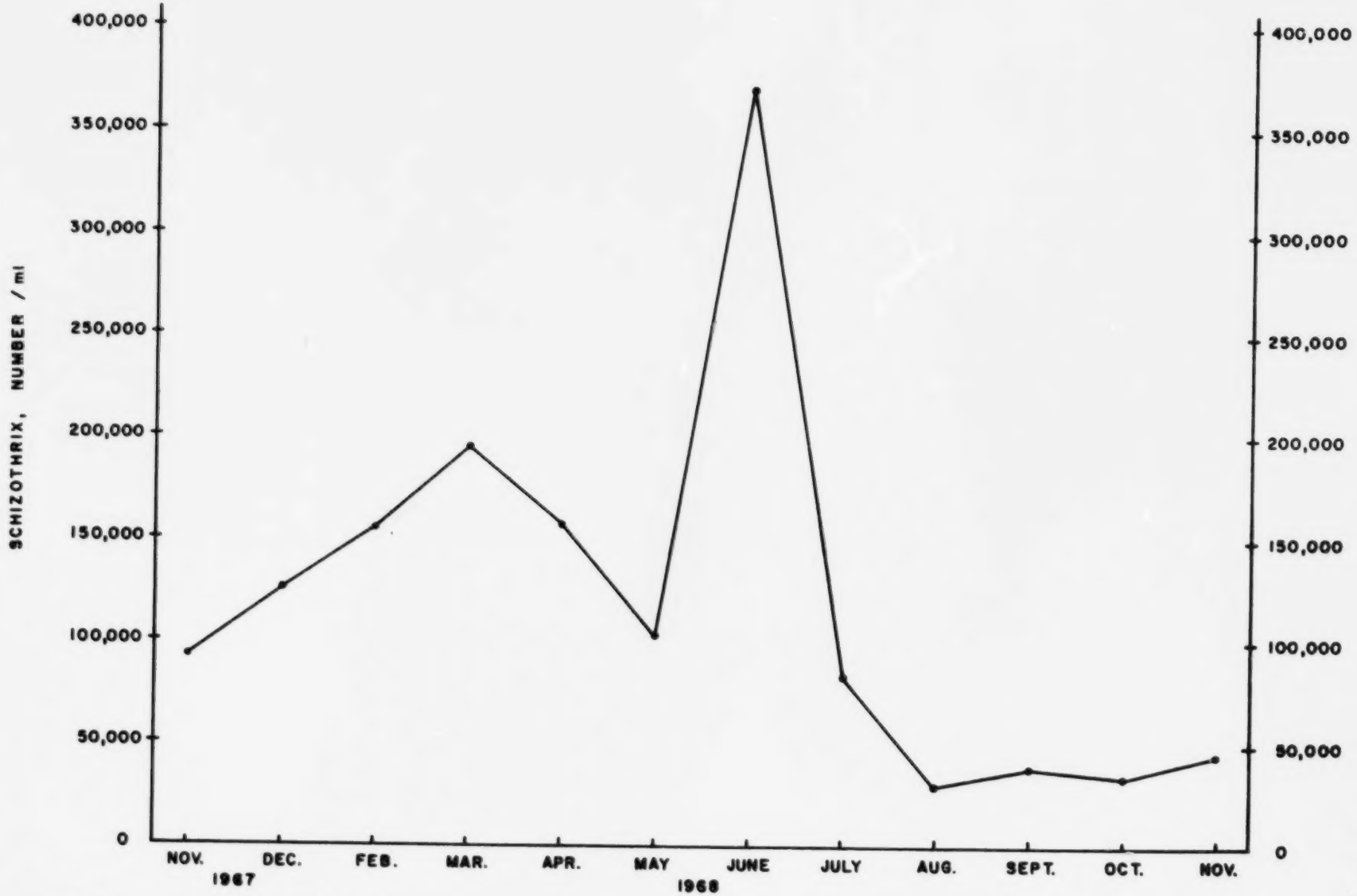


FIGURE 2 SCHIZOTHRIX, A PROBABLE TASTE AND ODOR-CAUSING BLUE-GREEN ALGA. GRAND LAKE, OHIO

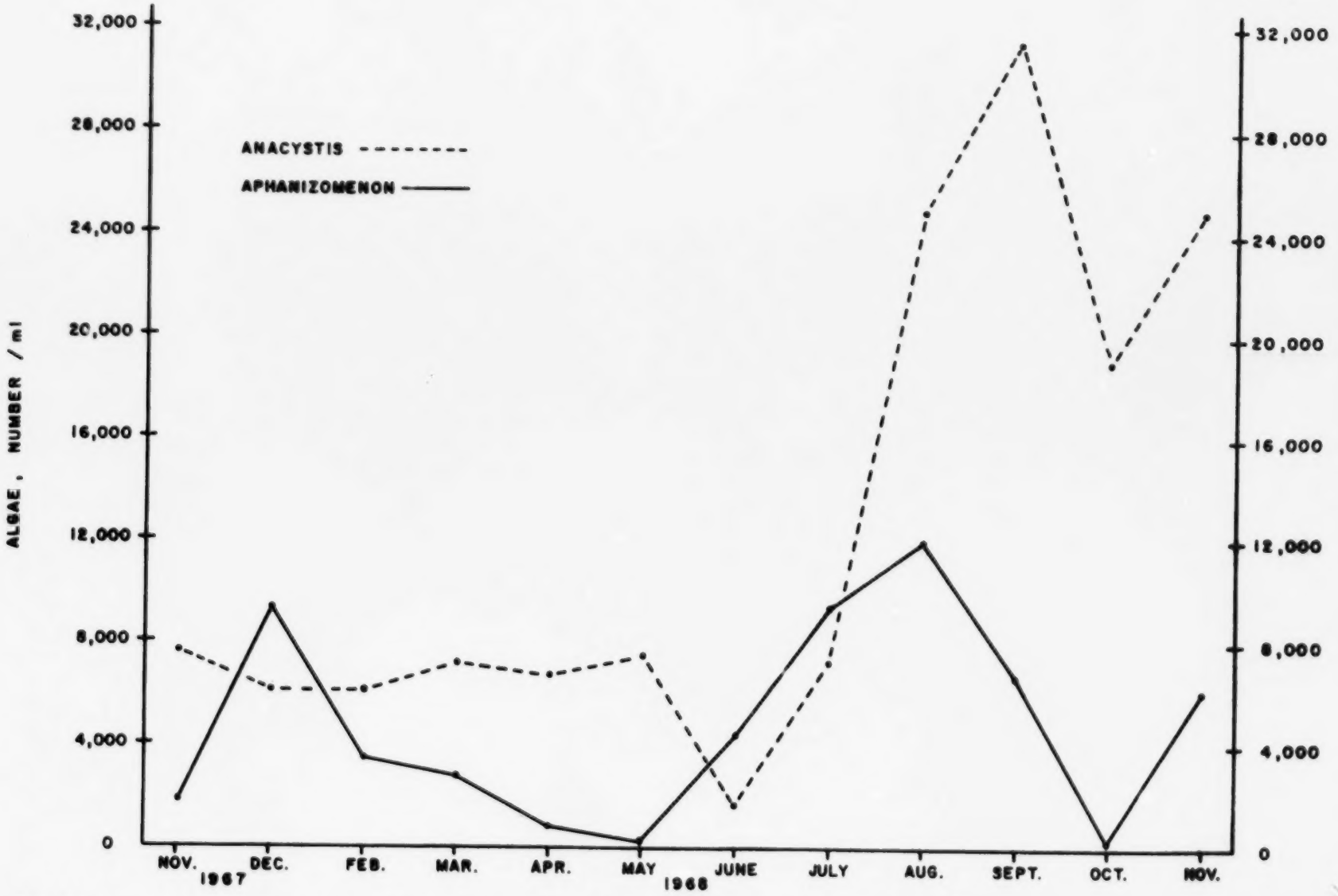


FIGURE 3 ANACYSTIS AND APHANIZOMENON, KNOWN TASTE AND ODOR-CAUSING BLUE-GREEN ALGAE. GRAND LAKE, OHIO

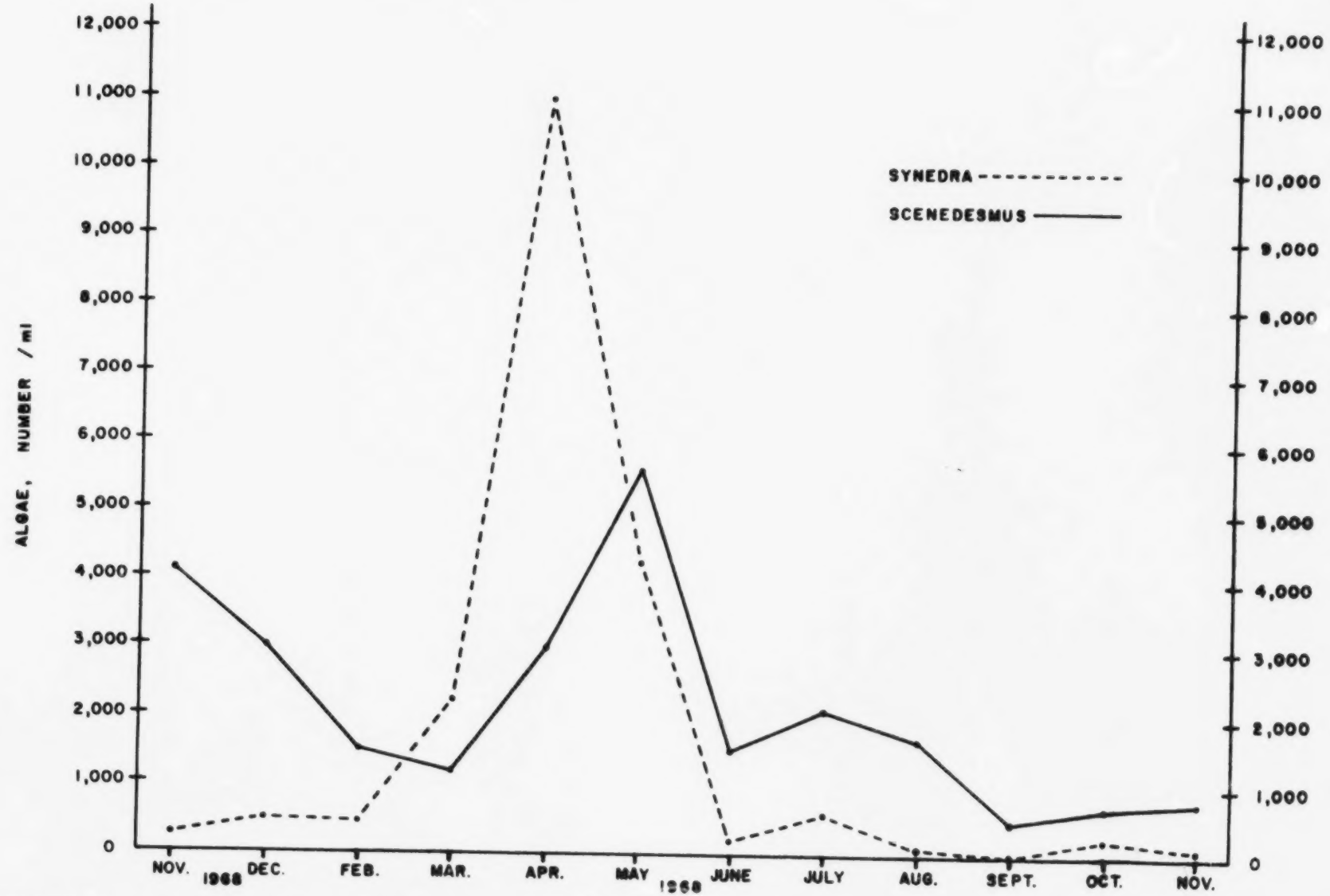


FIGURE 4 SYNEDRA AND SCENEDESMUS, TASTE AND ODOR-CAUSING ALGAE OTHER THAN BLUE-GREENS. GRAND LAKE, OHIO

The Schizothrix population remained high from November 1967 to May 1968, and rose even higher in June, after which there was an abrupt decline until August when it leveled off to a more stable condition (Figure 2). Aphanizomenon reached three population peaks: in December 1967, and in August and November 1968 (Figure 3). Anacystis on the other hand, remained rather constant (7,000 to 8,000/ml) during November 1967 to May 1968 and then dropped to 1,800/ml in June. By September, its numbers increased substantially to over 31,000/ml, with 19,000/ml recorded for October and 24,500/ml for November. Both Synedra and Scenedesmus showed their greatest population surge toward the latter part of the study in April and May, reaching a high of 11,050 and 5,606 algae/ml, respectively (Figure 4).

A survey of the algal data taken from the tributaries that empty into Grand Lake showed a marked similarity to the lake's algal population. This led to the conclusion that the sampling stations on the tributaries were situated too close to the lake permitting water from the lake to back up into the mouths of the tributaries. The samples were actually coming from the lake water, a fact that was not realized until the study was nearly completed. Because of this situation, the algal data from the tributaries were not considered and were discarded.

Heavy rains and snow prevailed in the area around Celina, Ohio throughout December 1967 and again toward the latter part of February and through most of March 1968, rendering the tributaries to the lake highly turbid. In February 1968, the actinomycetes count reached a high of 9,600/ml in the tributaries, and 29,600/ml in Grand Lake.

Table 3 - Threshold Odor Data

Sampling Date 1968	Sampling Stations and Odor Numbers				
	W-161 Grand Lake	W-133 Wabash, Ind.	W-89 Attica, Ind.	W-61 Terre H., Ind.	W-19 Mt. Carmel
February*	390	320	24	16	28
March	512	2	4	6	2
April	100	6	6	4	6
May	512	6	12	12	6
June	3200	100	16	24	12

* February determinations were made at room temperature. All others were made at 40°C.

Threshold odors in Grand Lake ranged from between 100 and 3200 and were far more intense than at any other sampling station. The most pronounced odors occurred in June, synonomus with a substantial increase in the filamentous blue-green alga Schizothrix calcicola (from 102,000/ml in May to 370,000/ml in June), which was consistently the most predominant alga in Grand Lake throughout the year.

Nutrient data collected from Grand Lake showed the concentrations of nitrate nitrogen, total phosphorus and soluble orthophosphate phosphorus to be consistently high. The average were 0.90 mg/l, 0.22 mg/l and 0.127 mg/l, respectively.

The greatest amount of nutrient material is supplied to the lake via the tributaries that drain hundreds of acres of rich agricultural land. There is also a certain amount of nutrient being discharged directly into the lake in the form of wastes from homes in the surrounding area. This is in part evidenced by the presence of linear alkyl benzene sulfonate (LAS), which was recorded to be 0.1 mg/l.

The dissolved oxygen concentration averaged 10.0 mg/l, but at no time during the study did it reach a point of supersaturation; the field pH ranged from 6.5 to 7.9 with the conductivity 370 micromhos/cm at 25 ^{o}C and the turbidity 37 JU.

WABASH RIVER STUDY

Background of Wabash Study

The investigation of the taste and odor problems in the Wabash River began on August 1, 1967, following a meeting of Evansville Office personnel with personnel from the Indiana State Board of Health, Indianapolis, Indiana and Technical Advisory and Investigations Branch, Cincinnati, Ohio. At this meeting we learned that during May and June of 1963 the city of Terre Haute, Indiana had experienced highly objectionable tastes and odors in its finished water supply and that the problem recurred in May and June of 1964, 1965 and 1966. By 1967 the city had converted to a groundwater source, which apparently eliminated the problem.

On May 21 and June 8, 9 and 10, 1964, the Indiana State Board of Health conducted an investigation; a summary of its findings is as follows:

1. Tastes and odors in the Wabash River at Terre Haute, Indiana seemed to be most severe during May and June and then dropped off rather abruptly to a more stable condition.
2. Originally industries upstream of Terre Haute were assumed to be the principal sources of tastes and odors. This assumption was discounted when it was learned that the threshold odor upstream of the industrial complex was identical to that of the downstream reach.
3. Mycological examination disclosed that no actinomycetes were present in the Wabash River. This is not to suggest that actinomycetes do not exist in the Wabash River, only that they were not identified at the time of the Board of Health's investigation.

4. Plankton counts numbered 85,000/ml of sample collected at the Terre Haute water intake in May 21, 1964; of this number 90 percent were types known to produce taste and odor in water.
5. Nutrient data gathered from nine stations on the Wabash River between Battleground, Indiana (5 miles north of Lafayette) and Terre Haute, Indiana, showed the average nitrate and phosphate content to be 0.76 mg/l and 0.22 mg/l respectively.
6. On the basis of the information listed, it was assumed the taste and odor problem at Terre Haute, Indiana was directly related to high concentrations of taste and odor-producing algae.

Other Problem Areas on the Wabash River

The August 1, 1967 meeting also revealed that prior to 1964, the city of Huntington, Indiana obtained most of its water from wells and that when the water treatment plant was rebuilt in 1964, the city converted to a surface water supply from the Wabash River. In 1965, the city had taste and odor problems in its raw water, with threshold odors reaching 400. Similar problems were encountered in the spring of 1966 and again in the spring of 1967.

On April 1, 1968 a visit was made by Evansville Office personnel to the Huntington Water Treatment Plant. During this visit, it was learned that the plant mixes approximately 75 percent of well water with 25 percent Wabash River water in order to offset tastes and odors. The percentage of well water used depends upon the odor threshold of the Wabash River.

On another occasion the Indiana State Board of Health officials were contacted by the Illinois Department of Health, in regard to tastes and odors encountered at Mt. Carmel, Illinois, on or about June 1, 1967. The Wabash River is Mt. Carmel's source of raw water.

As a result of these findings, the FWPCA recognized the need for a more detailed survey of the Wabash River. The survey was undertaken by the Lower Ohio Basin Office at Evansville, with technical assistance from the Technical Advisory and Investigations Branch in Cincinnati.

Approach to Wabash River Study

A review of past data showed that the most severe taste and odor problems in the Wabash River occurred during high-water periods and at times when the water temperature was rising (generally from April through the middle of June, depending upon flow conditions).

The first samples were collected on November 16, 1967 at a time well in advance of the period of high water and flooding, and sampling continued on a 4-6 week basis through the week of June 10, 1968 in the Wabash River and through the week of November 11 in Grand Lake. Table I gives a description of the stations that were sampled.

The discussion of the Wabash River will be treated in four major sections:

Headwaters to Huntington, Indiana
Huntington, Indiana to Lafayette, Indiana
Lafayette, Indiana to Terre Haute, Indiana
Terre Haute, Indiana to Mt. Carmel, Illinois

Wabash River from the headwaters to Huntington, Indiana - The first major tributary to the Wabash River is Beaver Creek. It receives its water from Grand Lake through the west spillway and also from Celina, Ohio's Sewage Treatment Plant.

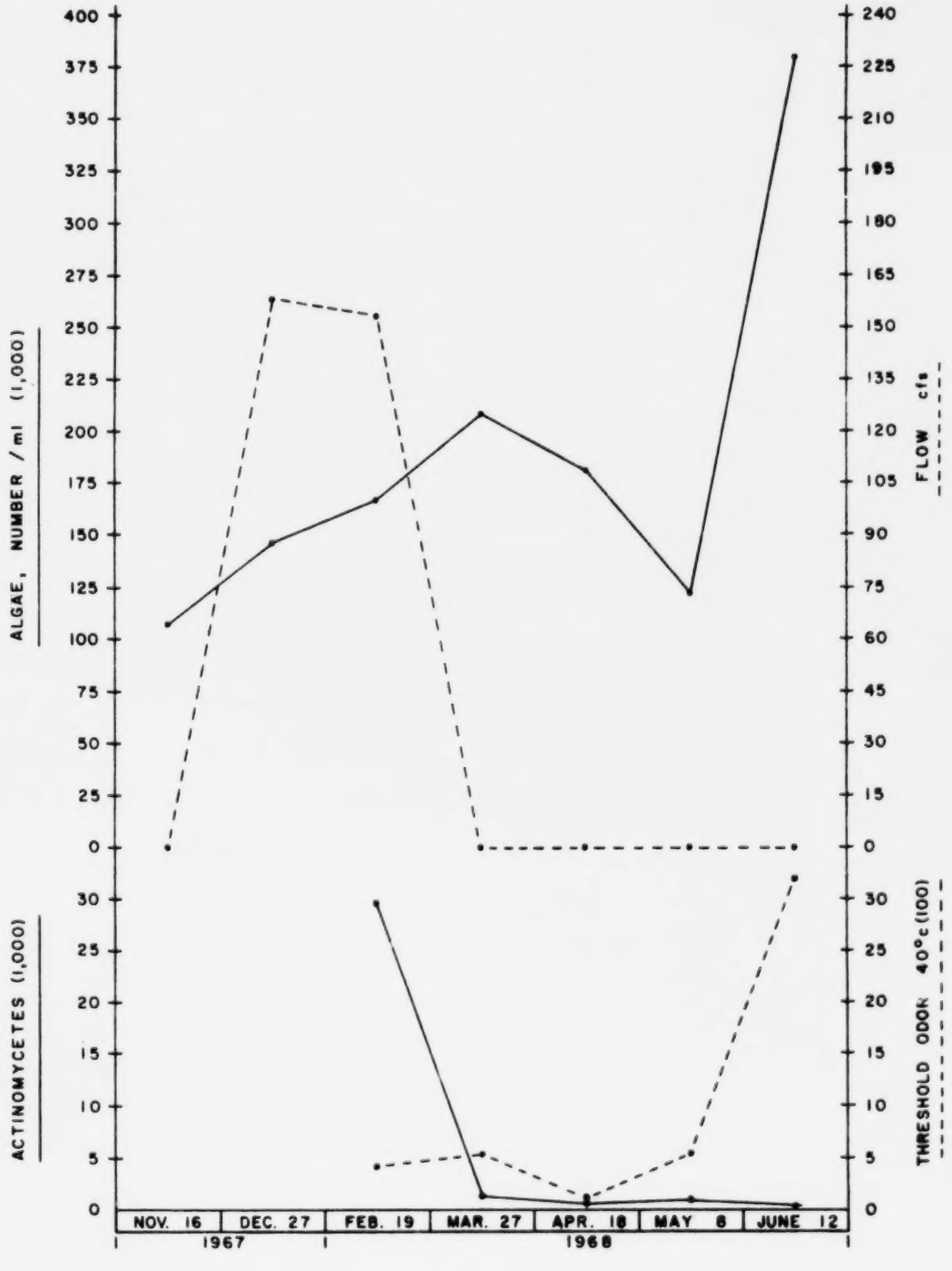


FIGURE 5 FLOW, THRESHOLD ODORS, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR-CAUSING ALGAE AT THE WEST SPILLWAY IN GRAND LAKE.

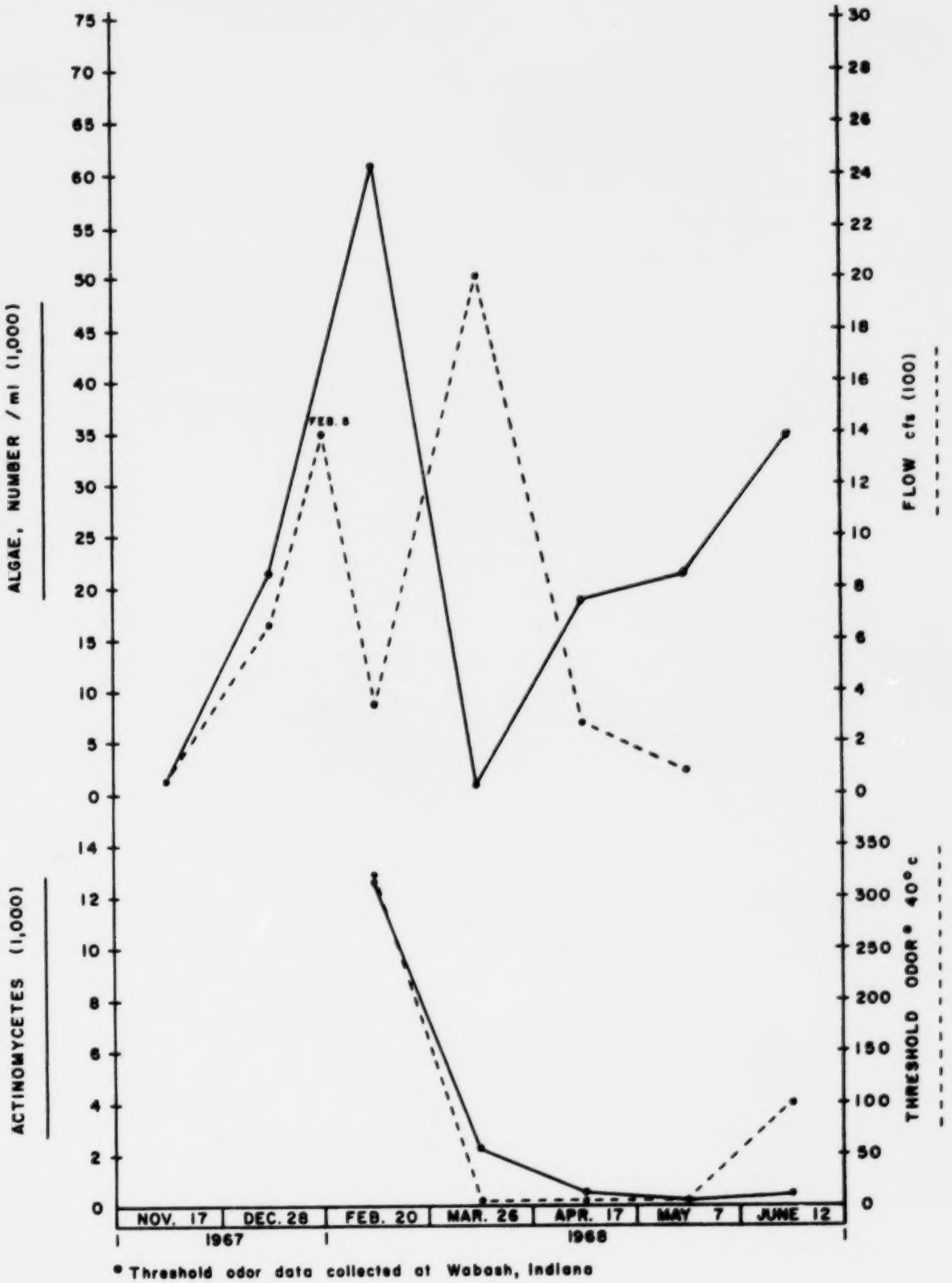


FIGURE 6 FLOW, THRESHOLD ODORS, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR - CAUSING ALGAE IN THE WABASH RIVER AT HUNTINGTON, INDIANA

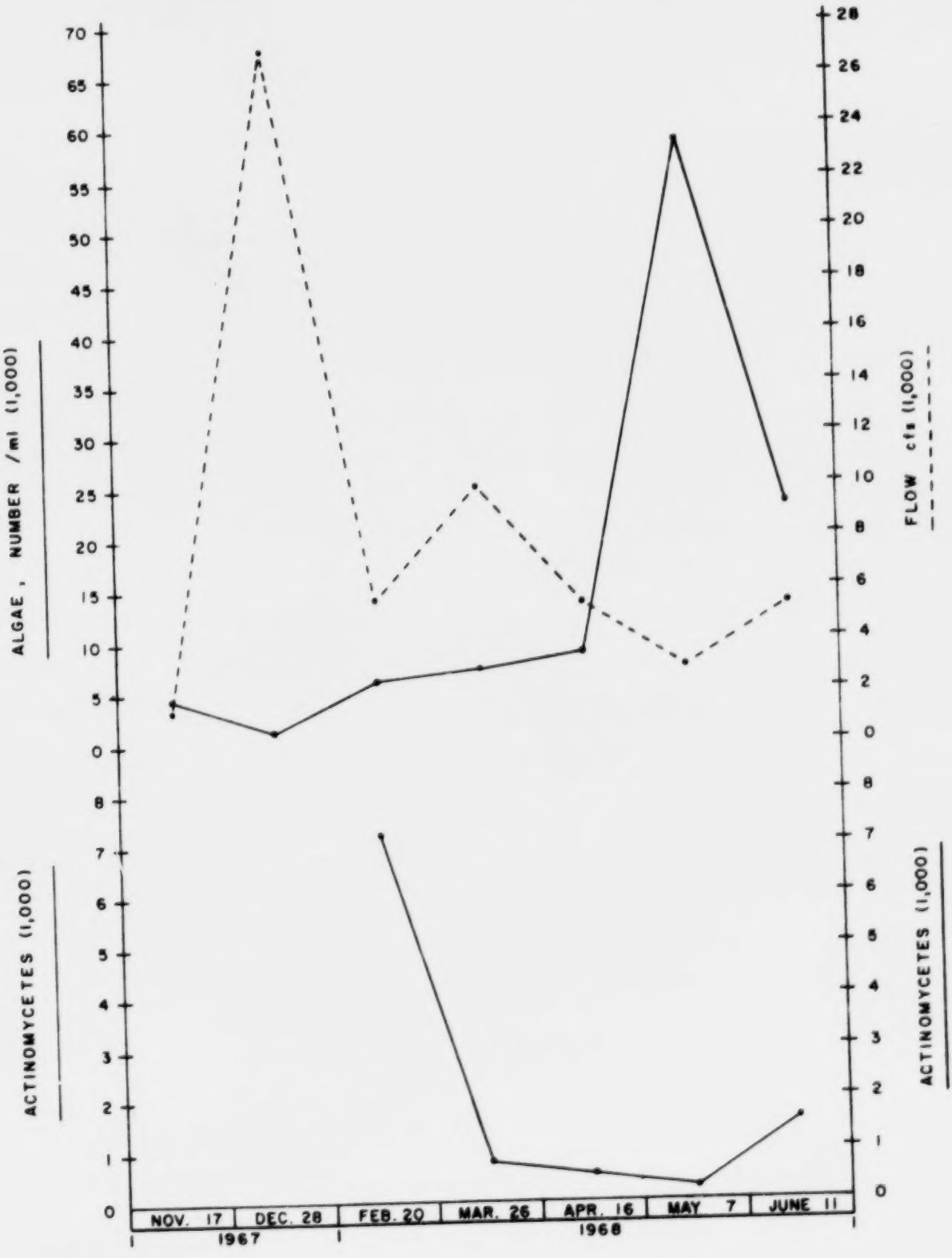
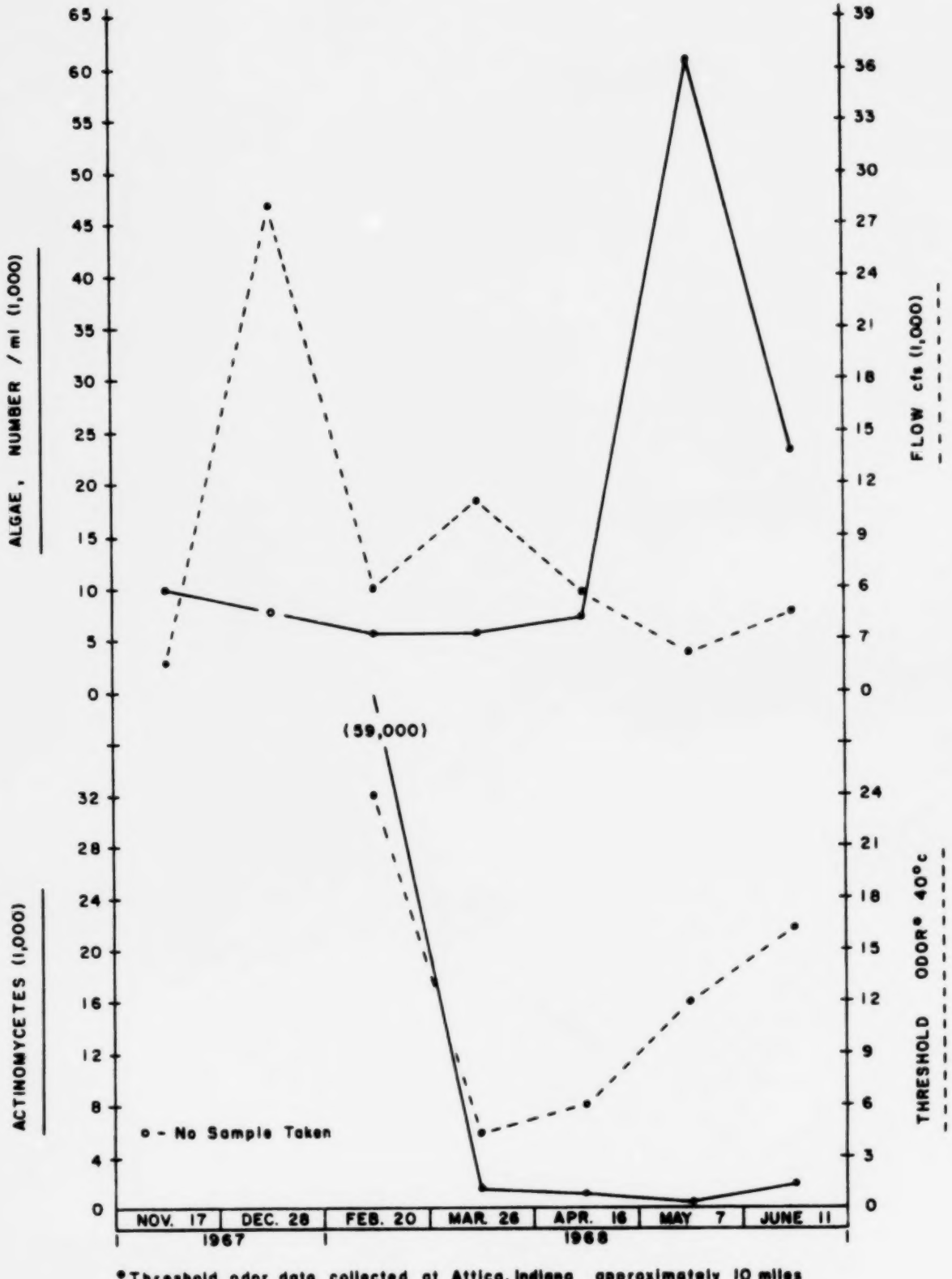


FIGURE 7 FLOW, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR-CAUSING ALGAE IN THE WABASH RIVER AT LAFAYETTE, INDIANA



*Threshold odor data collected at Attica, Indiana approximately 10 miles downstream from this station.

FIGURE 8 FLOW, THRESHOLD ODORS, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR-CAUSING ALGAE 10 MILES DOWNSTREAM FROM LAFAYETTE, INDIANA

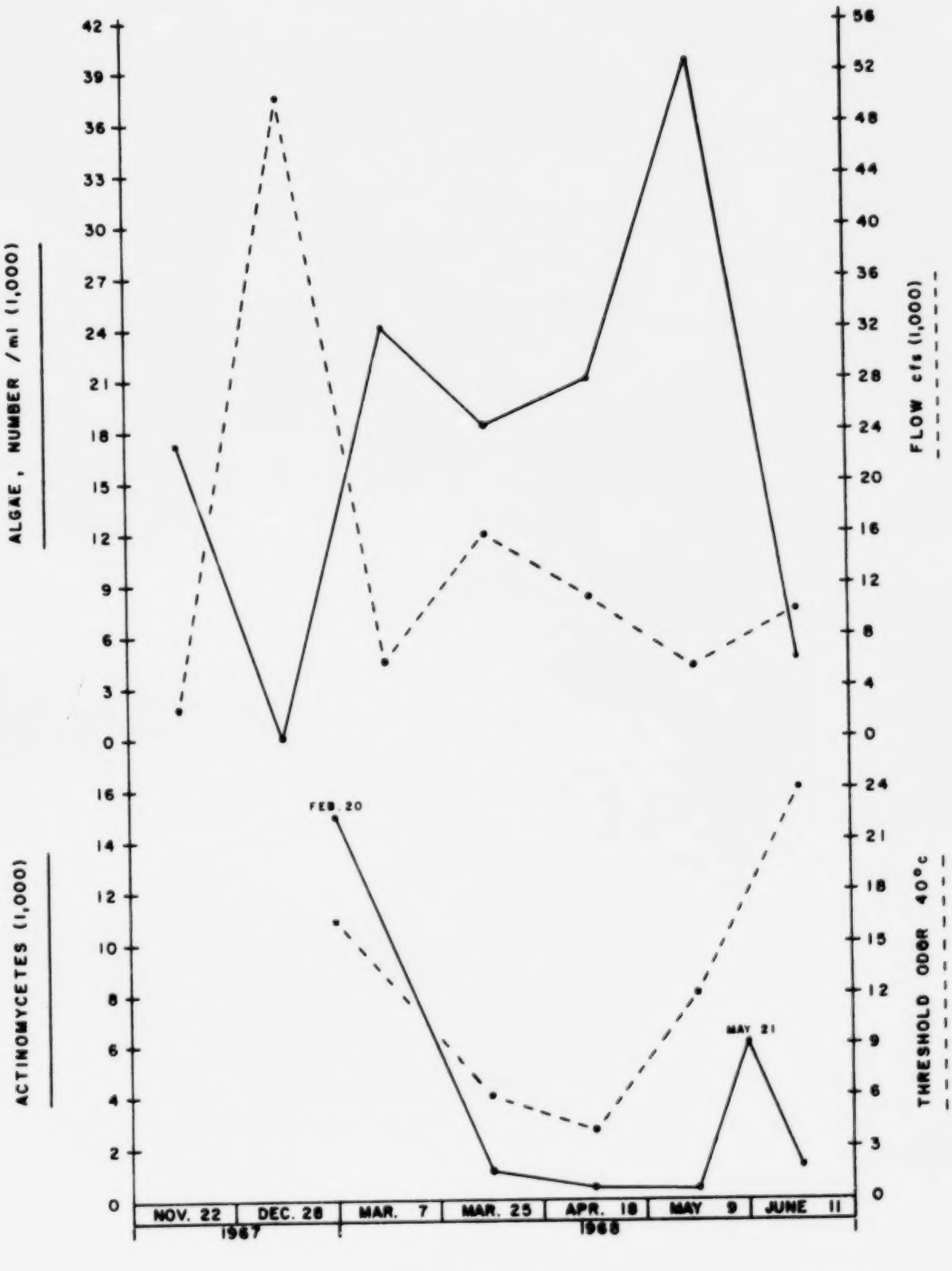


FIGURE 9 FLOW, THRESHOLD ODORS, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR-CAUSING ALGAE IN THE WABASH RIVER AT TERRE HAUTE, IND.

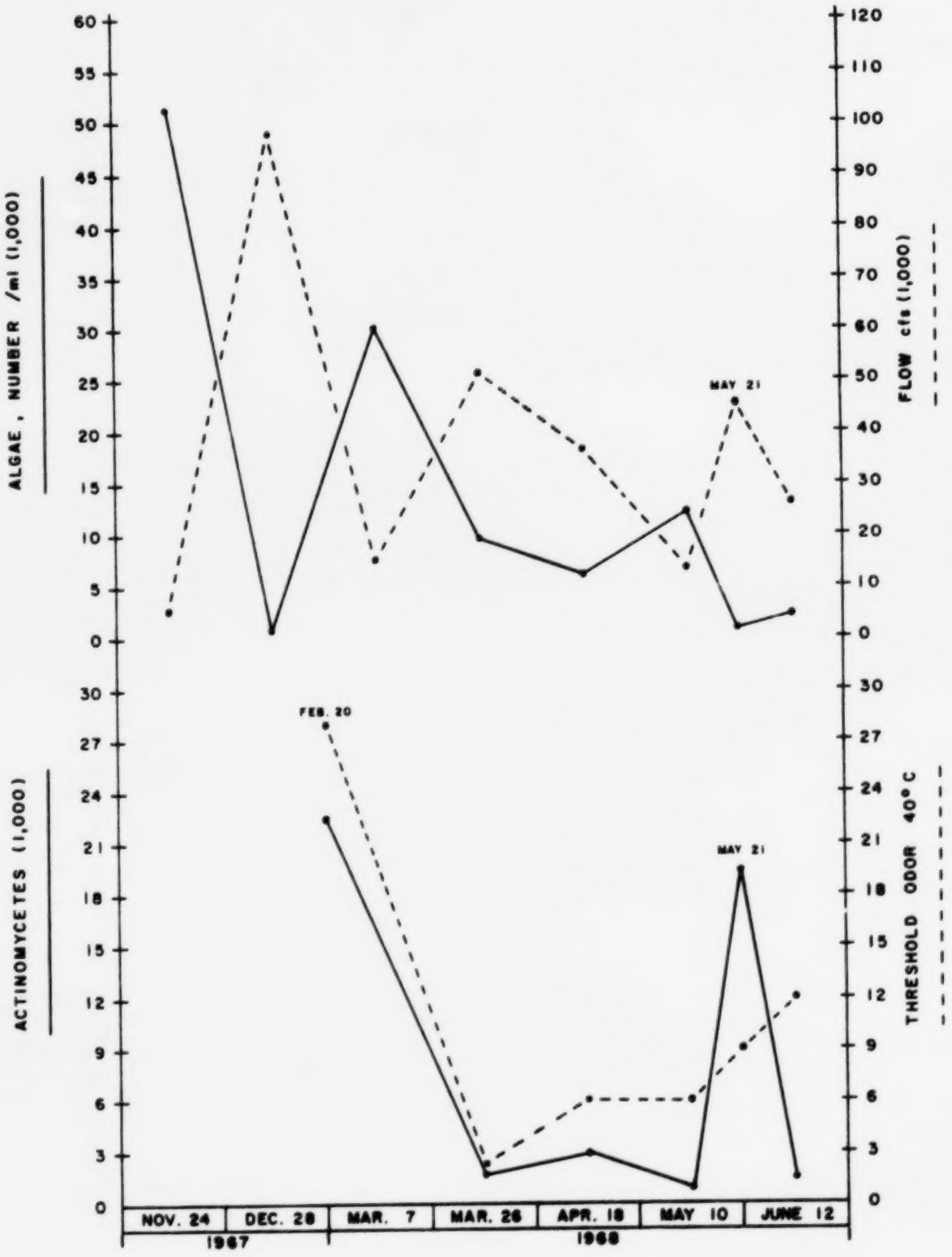


FIGURE 10 FLOW, THRESHOLD ODORS, ACTINOMYCETES AND KNOWN AND PROBABLE TASTE AND ODOR-CAUSING ALGAE IN THE WABASH RIVER AT MT. CARMEL, ILLINOIS

The sampling station on Beaver Creek was located some six to eight miles west of the city of Celina. The stream at this point showed evidence of adverse pollution by sewage effluent. This condition became most apparent during periods of low flow when the water appeared "dishwater" gray and a luxuriant growth of filamentous blue-green algae covered the substrate. The nutrient concentration was high with the nitrate nitrogen averaging 2.79 mg/l and the total phosphorus averaging 1.26 mg/l.

The reach of the Wabash River from the mouth of Beaver Creek to Huntington, Indiana, a distance of some 55 miles is located in a sparsely populated area where industrial and domestic waste problems are minimal. The major influence to the stream in this section, so far as tastes and odors are concerned, is from agricultural drainage and Grand Lake.

During the fall of 1967 the most predominant algae in the river around Huntington included a moderate population of flagellates as well as a few genera of greens, blue-greens, and diatoms. From December through mid-March, the blue-green algae were by far the most abundant; but with the advent of spring, they gradually gave way to greens, flagellates and diatoms (Figure 5).

Wabash River from Huntington, Indiana to Lafayette, Indiana- The city of Huntington experienced its most acute taste and odor problem during high water periods when a large amount of water was being discharged from Grand Lake. The composition of algae and actinomycetes in the river at Huntington during that time was nearly identical with that of the lake, and in numbers sufficient to impart acute tastes and odors to drinking water.

Later in the spring as the lake algae disappeared from the Wabash River at Huntington, the diatom Cyclotella, which is considered to be a taste and odor-producing alga began to fluorish until by June, it had reached a count of over 27,800 per ml. Any tastes and odors experienced by the city of Huntington during the late spring and summer are no doubt enhanced by the presence of Cyclotella. The actinomycete count for this same period was 320/ml. (Figure 6)

Six large tributaries enter the Wabash River along this reach. They are the Salamonie, Mississinewa, Eel and Tippecanoe Rivers and Wildcat and Deer Creeks. The largest cities associated with these tributaries are Kokomo, Indiana on Wildcat Creek and Marion, Indiana on the Mississinewa River.

Of the algae in these tributaries, the diatoms were the most predominant followed by the flagellates, greens and blue-greens. Among the diatoms the centric form Cyclotella was the most abundant, reaching a high of over 15,200/ml in Wildcat Creek in March 1968 and over 15,200/ml in the Eel River in May 1968. The actinomycetes were highest in the Mississinewa River with an average of 730/ml, and were lowest in Deer Creek with an average of 60/ml (Table 6). The nitrate nitrogen average for the six tributaries during May and June 1968 was 2.5 mg/l and the total phosphorus average for the same period was 0.083 mg/l (Table 5).

Occasionally substantial amounts of taste and odor-producing materials such as oil, foam and organic wastes in the form of sludge were observed.

The most significant oil deposit was at Logansport, Indiana. Here the water at times was completely covered with an oily film and was foul-smelling. Organic sludge seemed to be most prevalent in the vicinity of Richvalley (downstream from Wabash, Indiana), and Attica, Indiana, where globules of decaying organic material were seen floating on the surface of the water and sludge deposits were extensive.

A count of 60,400 actinomycetes/ml, the highest for the study, was recorded at Peru, Indiana, with the next highest count of 59,200/ml at station 95 downstream from Lafayette. These counts occurred on February 20, following a time when riverflow and land runoff was at a maximum for the year (Table 18).

The algal population at Huntington, Indiana reached two population peaks. The first occurred during January and February, at a time when the greatest flow was coming from Grand Lake. The algae in the river around Huntington at this time was identical to that of the lake with the blue-green group being the most predominant. The second peak was reached during the latter part of the survey in June. The algal population for this period was not at all related to that of the lake, but was more nearly similar to the actual or "natural" population of the river, with the diatoms and green algae being the most abundant. From this, it was concluded that the tastes and odors Huntington experienced in the late winter and early spring were caused principally by algae and actinomycetes that were being discharged from Grand Lake. This condition was accented by

actinomycetes that were carried into the river from land runoff during periods of high water and flooding. Taste and odor problems which occurred during May and June when flooding had stopped, were not related to lake discharge but were primarily the result of a "natural" population "bloom" with the taste and odor-causing diatom Cyclotella and the green alga Scenedesmus being the greatest contributors.

Wabash River from Lafayette, Indiana to Terre Haute, Indiana - This particular stretch of the river is of prime importance, since it was at Terre Haute where severe taste and odor problems in the past were most objectionable.

Current data gathered from this part of the river showed that algae were adversely affected by streamflow. That is, during the months of December and January when flows were high, the algae were low; conversely, as the water receded, the number and kinds of algae gradually increased, until by mid-May, a definite "bloom" had occurred. Among the algae comprising the "bloom", those suspected of causing tastes and odors were the most abundant and totaled some 40,000 per ml, a number sufficiently high to impart bad tastes to drinking water supplies. The most predominant among these algae were Cyclotella, Scenedesmus, Synedra and Schizothrix in that order. (Figure 9)

The actinomycetes, unlike the algae were far more abundant during periods of flooding. The highest count (59,200/ml) was recorded downstream from Lafayette on February 20, with 14,800 actinomycetes/ml recorded at Terre Haute for the same period. By May 9 the actinomycetes at Terre Haute had decreased to 240/ml, but then increased to 8,400/ml during the latter part of May (Figure 9) following a short period of flooding.

Since converting to well water in 1967, the city of Terre Haute is dependent upon the Wabash River only as a supplementary source. Therefore, it was impossible to know if a taste and odor problem existed during April, May and early June of 1968 as had occurred in previous years. However, from data gathered during the present study, it was learned that in addition to a high algal population during the months of April, May and early June in the vicinity of Terre Haute, there were also substantial amounts of actinomycetes, whose numbers increased markedly following periods of flooding. From this information, it seems reasonable to assume that a characteristic spring algal "bloom" along with actinomycetes very likely could have been the major cause of Terre Haute's taste and odor problem. Moreover, if the period of springtime flooding in the Upper Wabash Basin is extensive and of a long duration, large numbers of Grand Lake algae are detected as far downriver as Terre Haute and even beyond. Such was the case in June 1967 when filamentous blue-green algae comprised almost entirely of Schizothrix calcicola were recorded in excess of 15,000 per ml. By comparison, during June 1968 flooding was not nearly so intense and consequently, the filamentous blue-green count was substantially less (450/ml). Certainly these algae, when present in large numbers would be of concern as a contributing factor toward the taste and odor problems previously experienced in this reach of the river.

Nutrients throughout this section were far in excess of what is required to establish and maintain a substantial algal population (Table 14).

Wabash River from Terre Haute, Indiana to Mt. Carmel, Illinois - Mt. Carmel, Illinois, the only city within this reach that uses the Wabash River for its drinking water supply experiences its most severe taste and odor problems in the early spring when the river is high. A less severe problem is generally experienced again in the late summer and fall.

Algal data gathered at Mt. Carmel, Illinois during November 1967 showed a concentration of over 58,000 algae per ml, many of which are known to produce tastes and odors. Another smaller plankton "pulse" of some 30,000 algae per ml was recorded in March. There was no characteristic spring "bloom" in May or June similar to that which occurred at various upstream stations. This reduction in the algal population was likely due to intensive rains and flooding locally during these months. In contrast, the actinomycete population was highest during periods of extensive flooding, which occurred in February and again in May (Figure 10). Concentrations of 22,400 and 19,200 actinomycetes/ml were recorded for those months.

From these data it appears that the actinomycetes were the principle organisms responsible for Mt. Carmel's 1968 springtime taste and odor problem, while algae, primarily the diatom Cyclotella were greatly responsible for tastes and odors during the summer and fall.

Cannery Lagoons on the Wabash River

A number of tomato canneries are located in the Upper Wabash Basin, and effluent from these canneries are stored in lagoons that are generally emptied during high flow periods into streams tributary to the Wabash River. These lagoons were considered as a possible source of tastes and odors,

since the majority of the wastes either enter the Wabash River directly, or into one of its tributaries.

Samples were collected from eight of these lagoons (Table 17) to determine the nutrient content as well as the algal and actinomycetes composition. Of these eight lagoons, one empties into the Wabash River, three into the Salamonie River, and four into the Mississinewa River.

A dense population of algae, composed almost entirely of the green alga Chlorella and the green flagellate Chlamydomonas was present in nearly all of the lagoons; but since their numbers in the Wabash River were low, it is doubtful that they were very influential in contributing to the tastes and odors in the river. The actinomycetes from the lagoons averaged 300/ml and are believed to have little effect on the overall taste and odor problem within the Wabash River.

ACKNOWLEDGEMENTS

Thanks are extended to the water treatment plant personnel at Celina, Ohio; Huntington, Indiana; Terre Haute, Indiana; and Mt. Carmel, Illinois for providing data relative to this report; to Dr. Robert Safferman, Dr. Aaron Rosen and Mr. Charlie Mashni, FWPCA, Cincinnati for their constructive criticism and comments; to the Technical Advisory and Investigations Section in Cincinnati who served as consultants; and to the laboratory and clerical personnel at the Lower Ohio Basin Office for their contribution in bringing this study to its completion.

APPENDIX

METHODS AND PROCEDURES

Phytoplankton

Phytoplankton samples were collected in midstream in 1 liter size plastic containers at a depth of 4-6 inches beneath the surface of the water. One sample per station was obtained during each sampling run.

The strip count method, using the Sedgwick-Rafter counting cell was used. Two longitudinal strips, the width of a Whipple ocular grid were scanned at 200 x magnification. The number obtained from counting two strips was then multiplied by an appropriate factor to obtain the total algae per milliliter of sample.

Each individual cell or natural colony of cells was counted as one unit, while filamentous forms were counted as filaments each equal to one unit and unnatural colonies and clumps of cells were counted as clusters which were also equivalent to one unit. All counts were recorded in terms of numbers per ml.

Samples were preserved with 5 ml/l of 5% mercuric chloride.

Actinomycetes - Collection and Preservation

All samples were collected in sterile 300 ml ground glass hooded stoppered bottles.

Grab samples were taken at the surface in midstream and along each bank of the river at each sampling station for composites and held at 5°C until tested. Where only one sample was taken, it was taken in midstream at the surface.

The lake samples and samples from the lagoons were taken from surface water along the bank and held at 5° C until tested.

No samples were stored longer than 48 hours before being plated out.

Samples were collected monthly from February 19, 1968 to June 13, 1968.

Actinomycetes - Preparation of Materials and Laboratory Methods

Egg Albumin Agar was prepared by carefully weighing out 1.0 gm of glucose (dextrose), 0.25 gm soluble egg albumin, 0.5 gm K_2HPO_4, 0.2 gm $MgSO_4 \cdot 7H_2O$, 0.01 gm $Fe_2(SO_4)_3 \cdot 7H_2O$, and 15.0 gm of agar. Each of the nutrients was added in turn, to a 2,000 ml Erlenmeyer flask containing 1,000 ml of distilled water. After the agar was introduced into the flask, the medium was heated by placing the flask in a container of boiling water, in order to prevent agar granules from burning or sticking to the vessel. As soon as the agar was dissolved, the medium was dispensed into 500 ml Erlenmeyer flask (250 ml aliquots) and 50 ml test tubes (17 ml aliquots). The flasks and tubes were capped with aluminum foil.

Water Dilutions Blanks were prepared in 150 ml screw cap bottles to which 90 ml of tap water was added. The bottles were loosely capped to avoid breakage from excessive vapor pressure produced during sterilization.

Actidione, an antifungal antibiotic produced by UpJohn and Company, Kalamazoo, Michigan[1] was added to the medium just prior to plating to suppress fungal development. A stock solution of the antibiotic was prepared at a concentration of 1 mg per ml of distilled water.

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[1] The mention of commercial sources or products does not constitute endorsement by the Federal Water Pollution Control Administration.

The culture media and water blanks were sterilized at 15 psi steam pressure (121° C) for 20 minutes and the Actidione stock solution for 15 minutes and then cooled to room temperature and stored at 5° C until ready for use. The final pH of the egg-albumin agar after sterilization was 7.1.

Actinomycetes - Isolation and Enumeration

Composites were made from the three grab samples collected from each sampling station unless noted otherwise. After the composite sample was thoroughly mixed, a 10 ml aliquot was immediately withdrawn and transferred to a 90 ml sterile water dilution blank in a 150 ml bottle and shaken vigorously for 15 seconds - 10 ml of the 1:10 dilution were pipeted into another 150 ml bottle containing 90 ml sterile tap water and shaken vigorously for 15 seconds to give a 1:100 dilution. A 10 ml aliquot was then immediately withdrawn, transferred into a 90 ml water dilution bottle and shaken to give a 1:1,000 dilution. Ten-fold dilutions up to 1:1,000 were sufficient for the water samples.

Of the methods available for enumerating microbial populations, the plate count is generally considered the most reliable. The use of a solid medium permits formation of colonies, which in the case of the actinomycetes can be enumerated by the observation of certain differential characteristics. To facilitate the identification and counting of actinomycete colonies, a two-layer agar plate was adopted for these studies. As only the thin upper layer was innoculated, the technique assured a predominance of surface colonies.

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The bottom, or basal layer consists of 15 ml of uninoculated medium. This was prepared by dispensing a flask of sterile egg albumin agar in boiling water and then pipetting a 15 ml aliquot of the melted agar onto a sterile petri plate, opening the petri plate only long enough to introduce the agar. After the basal layer has solidified, 7 ml of inoculated agar was then introduced into the plate.

The surface layer was prepared in a test tube containing 17 ml of sterile egg albumin agar that was previously melted and cooled to 45° C in a constant-temperature water bath. A 2.0 ml aliquot of the appropriate diluted sample and 1.0 ml of the Actidione stock solution (1 mg/ml) was added to the test tube. This resulted in a final volume of 20 ml and an Actidione concentration of 0.05 mg per ml of medium. When pipetting 7 ml of the inoculated medium over the basal layer of the plate, the medium was gently swirled so that an even distribution of the surface layer was obtained. Dilutions made from each of the composite samples were plated out in triplicate.

Plates were incubated at 45° C for 7 days and then counted to determine the actinomycete population of the sampled area. The population was determined by:

1. Averaging the actinomycete counts in each set of triplicate plates from those dilution plates in which the total number of colonies were between 30 and 300.
2. Multiplying this average by the serial dilution number of the particular plate.

3. Multiplying the product resulting from Step 1 and 2 by a factor of 4. This took into account the fact that only 5 ml aliquots of the 20 ml innoculum were added to each plate (1:4 dilution).

4. The final product represented the number of actinomycetes per ml.

Threshold Odor

Threshold odor samples for the month of February 1960 were analyzed at room temperature by the Technical Advisory and Investigations Branch at Cincinnati, Ohio. The remaining determinations were made at 40° C in the Evansville laboratory using the procedure outlined in the 1965 edition of Standard Methods (Table 3).

The [illegible]

Procedures outlined in the FWPCA Official Interim Methods (1970), the Journal American Waterworks Association, vol. 58, pp. 1503 (1966), and Standard Methods (10th edition) were used to determine total phosphorus, soluble phosphorus, and soluble orthophosphate phosphorus. Nitrate nitrogen data include nitrite + nitrate nitrogen. This method, automated on the Technicon AutoAnalyzer, was taken from the publication by Mashhake, Mannah and Cohen entitled "Water Research" published by Pergamon Press (1967). This same procedure can also be found in the FWPCA Official Interim Method (1970).

Ammonia nitrogen - a phenol hypochlorite method, using sodium nitroprusside as color was used. The results were determined using the Technicon AutoAnalyzer.

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Total Kjeldahl nitrogen (TKN), which is defined as the sum of free ammonia and of organic nitrogen compounds which are converted to $(NH_4)_2SO_4$ under specified conditions of digestion was determined using the procedure outlined in the FWPCA Official Interim Methods (1969).

The YSI Model 51 Oxygen Meter was used to determine dissolved oxygen and water temperature; the PORTO-matic Model 175 Meter for pH; and the Beckman RB-5 Meter for conductivity. Turbidity was determined by using the Hach Model 1860 Turbidimeter.[1]

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[1] The mention of commercial products or equipment does not constitute endorsement by the Federal Water Pollution Control Administration.

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Table 1 - Sampling Stations

Station Number	Location
W-161	Grand Lake, Celina, Ohio
W-157	Beaver Creek, Burrville Road East of Wabash, Ohio
W-155	Wabash River, Indiana - Ohio State Line
W-151	Wabash River, Main Street Bridge, Bluffton, Indiana
W-146	Wabash River, Highway 9-37, Huntington, Indiana
W-133	Wabash River, Highway 15, Wabash, Indiana
W-129	Wabash River, Wayne Street, Peru, Indiana
W-117	Wabash River, Cicott Street Bridge, Logansport, Indiana
W-99	Wabash River, North 9th Street Road, Lafayette, Indiana
W-95	Wabash River, 700 W. Road, 10 mi. S.W. Lafayette, Indiana
W-89	Wabash River, Highway 41, Attica, Indiana
W-79	Wabash River, Highway 234 near Cayuga, Indiana
W-71	Wabash River, Highway 63, Clinton, Indiana
W-61	Wabash River, Highway 40, Terre Haute, Indiana
W-60A	Wabash River, Interstate 70, Terre Haute, Indiana
W-45	Wabash River, Merom, Indiana
W-33	Wabash River, Highway 50, Vincennes, Indiana
W-19	Wabash River, Highway 64, Mt. Carmel, Illinois
W-10	Wabash River, Highway 460, New Harmony, Indiana
CL-1	Chickasaw Creek, Tributary to Grand Lake
CL-2	Prarie Creek, Tributary to Grand Lake
Cl-3	Beaver Creek, Tributary to Grand Lake
CL-4	Coldwater Creek, Tributary to Grand Lake

Table 1 - Sampling Stations (cont'd)

Station Number	Location
SAL-1	Salamonie River, Near mouth - tributary to Wabash River
SAL-2.5	Salamonie River, Indiana Highway 124 and 221
SAL-15	Salamonie River, Portland, Indiana
TIP-1	Tippecanoe River, Near mouth - tributary to Wabash River
WIL-1	Wildcat Creek, Near mouth - tributary to Wabash River
DER-1	Deer Creek, Near mouth - tributary to Wabash River
EEL-1	Eel River, Near mouth - tributary to Wabash River
MIS-1	Mississinewa River, Near mouth - tributary to Wabash River
MIS-10.5	Mississinewa River, Jonesboro, Indiana
LG-1	Geneva Lagoon, Geneva, Indiana
LG-2	Portland Lagoon, Portland, Indiana
LG-3	Plumtree Lagoon, Plumtree, Indiana
LG-4	Redkey Lagoon, Redkey, Indiana
LG-5	Upland Lagoon, Upland, Indiana
LG-6	Converse Lagoon, Converse, Indiana
LG-7	Warren Lagoon, Warren, Indiana
LG-8	Eaton Lagoon, Eaton, Indiana

Table 2 - Nitrogen and Phosphorus Data, Grand Lake and Tributaries

	1967 Dec.	Feb.	Mar.	1968 Apr.	May	June
Mg/l			Grand Lake			
Nitrate N	1.5	1.25	1.5	0.78	0.23	0.1
Total P	0.12	0.51	0.17	0.18	0.23	0.17
Sol. Ortho-P	0.047	0.42	0.078	0.037	0.10	0.03
	Jan.	Feb.	Mar.	Apr.	May	June
			Chickasaw Creek			
Nitrate N	4.7	4.4	6.5	2.8	0.28	1.7
Total P	0.077	0.35	0.25	0.24	0.19	0.24
Sol. Ortho-P	0.030	0.28	0.13	0.15	0.072	0.15
			Prarie Creek			
Nitrate N	4.3	2.9	7.7	4.2	0.53	3.0
Total P	0.37	0.22	0.26	0.22	0.39	0.32
Sol. Ortho-P	0.26	0.12	0.16	0.10	0.30	0.12
			Beaver Creek			
Nitrate N	3.0	2.9	6.6	3.4	0.1	1.3
Total P	0.07	0.20	0.22	0.18	0.28	0.30
Sol. Ortho-P	0.79	0.093	--	0.060	0.16	0.10
			Coldwater Creek			
Nitrate N	4.6	1.2	5.3	1.1	0.1	0.40
Total P	0.40	0.12	0.71	0.29	0.31	0.25
Sol. Ortho-P	0.47	0.048	0.64	0.092	0.14	0.105

Also see Table 14 and 15 for complete chemical data.

Table 4 - Percent of known and probable Taste and Odor-Causing Algae to the Total Algal Population in Grand Lake

Algae, Number/ml	1967 Nov.	Dec.	1968 Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Blue-Green Algae	%	%	%	%	%	%	%	%	%	%	%	%
Schizothrix calcicola*	77.0	82.0	90.0	90.0	83.0	79.0	97.0	76.0	38.0	44.0	57.0	54.0
Anacystis sp.	6.0	4.0	3.0	3.0	4.0	6.0	0.4	7.0	32.0	36.0	32.0	29.0
Aphanizomenon sp.	2.0	6.0	2.0	2.0	0.4	0.2	1.0	8.0	16.0	8.0	0.4	7.0
Gomphosphaeria sp.	0.6	0.6	8.5	0.4	0.7	0.6	0.2	2.0	3.0	2.0	0.4	3.0
Coccochloris sp.	0.5	0.4	0	0	0	0	0	0	0	0	0	0
Green Algae												
Scenedesmus sp.	3.0	2.0	0.9	0.6	2.0	4	0.4	2.0	2.0	0.6	1.0	1.0
Dictyosphaerium sp.	0.3	0	<0.1	0.1	0.5	0.9	<0.1	0.2	<0.1	0.1	0.2	2.0
Pediastrum sp.	0.4	0.4	0	<0.1	0.4	0.4	<0.1	0.2	<0.1	0.3	0.4	0.2
Desmids												
Staurastrum sp.	0.5	0.2	0	<0.1	0.1	0	0	0.1	<0.1	0	0.1	0
Cosmarium sp.	0.4	0	0	0	0	0	0	0	0	0	0.2	0
Flagellates												
Chlamydomonas sp.	0.2	0.2	0.2	0.4	<0.1	0.1	<0.1	0.6	0.2	0.2	0	0
Euglena sp.	<0.1	<0.1	0	0	0	0.2	<0.1	0.2	0.4	0.1	0	0.2
Cryptomonas sp.	0.7	2.0	<0.1	0.1	0.1	0	<0.1	0.3	0.7	0	0	0
Mallamonas sp.	0	<0.1	<0.1	0	0	0	0	0	0	0	0	0
Diatoms												
Cyclotella sp.	0	0	0.5	0	0.1	0.2	0	0	<0.1	0	0.5	0.4
Synedra sp.	0.2	0.3	0.3	1.0	6.0	3.0	<0.1	0.5	<0.1	0	0.4	<0.1

* A probable taste and odor-causing alga

Note - Although Schizothrix calcicola has not yet been proven scientifically to produce taste and odor compounds, nevertheless, by nature of its extreme abundance in Grand Lake throughout the year, and because it is related to species that are taste and odor producers it is considered a probable taste and odor producer.

Table [illegible] - Nitrogen and phosphorus determinations for the tributaries to the Wabash River

Location	Nitrate Nitrogen Mg/l		
	4-16-68	5-7-68	6-11-68
Salamonie River (Sal-1)	--	3.4	4.2
Mississinewa River (Mis-1)	3.6	1.2	1.9
Eel River (Eel-1)	--	0.90	1.9
Tippecanoe River (Tip-1)	--	1.2	3.1
Wildcat Creek (Wil-1)	--	2.3	4.7
Deer Creek (Der-1)	--	1.9	4.2

Location	Total Phosphorus Mg/l		
	4-16-68	5-7-68	6-11-68
Salamonie River (Sal-1)	--	0.063	0.064
Mississinewa River (Mis-1)	0.28	0.085	0.12
Eel River (Eel-1)	--	0.041	0.060
Tippecanoe River (Tip-1)	0.10	0.049	0.057
Wildcat Creek (Wil-1)	--	0.086	0.135
Deer Creek (Der-1)	--	0.090	0.13

Table 6 - Algae and actinomycetes counts for the tributaries to the Wabash River

Location	Total Algae, Number/ml			
	3-26-68	4-16-68	5-7-68	6-11-68
Salamonie River (Sal-1)	950	2,700	1,900	850
Mississinewa River (Mis-1)	4,300	2,300	4,200	3,500
Eel River (Eel-1)	1,500	5,100	17,900	15,500
Tippecanoe River (Tip-1)	11,200	9,900	7,300	12,600
Wildcat Creek (Wil-1)	17,200	2,100	8,200	40,500
Deer Creek (Der-1)	6,300	10,400	3,600	5,700

Location	Actinomycetes, Number/ml		
	4-16-68	5-7-68	6-11-68
Salamonie River (Sal-1)	160	240	400
Mississinewa River (Mis-1)	480	120	1,600
Eel River (Eel-1)	--	120	160
Tippecanoe River (Tip-1)	240	160	120
Wildcat Creek (Wil-1)	--	120	240
Deer Creek (Der-1)	--	40	80

Table 7 - Nitrogen and Phosphorus Data, Wabash River

	1967		1968				
Mg/l	Nov.	Dec.	Feb.	Mar.	Apr.	May	June
			W-157 Beaver Creek				
Nitrate N	4.4	1.3	1.25	6.2	2.8	1.4	2.2
Sol. Ortho-P	3.3	0.037	0.15	0.24	0.68	1.05	0.99
Total P	3.4	0.32	0.26	0.40	1.2	1.5	1.7
			W-155 Indiana-Ohio State Line				
Nitrate N	2.4	2.1	1.4	7.0	3.0	0.81	1.9
Sol. Ortho-P	0.91	0.12	0.17	0.19	0.19	0.245	0.11
Total P	0.99	0.25	0.27	0.43	0.33	0.38	0.33
			W-151 Bluffton, Indiana				
Nitrate N	4.2	3.2	1.65	6.4	2.6	0.31	2.0
Sol. Ortho-P	0.20	—	0.13	0.10	0.092	0.078	0.135
Total P	0.28	0.29	0.175	0.30	0.20	0.17	0.33
			W-146 Huntington, Indiana				
Nitrate N	3.8	3.8	2.2	7.0	3.3	0.1	2.1
Sol. Ortho-P	0.25	0.072	0.12	0.15	0.105	0.042	0.042
Total P	0.29	0.27	0.21	0.29	0.20	0.13	0.15
			W-133 Wabash, Indiana				
Nitrate N	3.2	3.5	3.1	6.4	3.5	0.48	2.3
Sol. Ortho-P	0.23	0.033	0.37	0.082	0.11	0.086	0.045
Total P	0.30	0.47	0.50	0.24	0.24	0.22	0.16
			W-129 Peru, Indiana				
Nitrate N	1.5	3.8	3.3	5.9	3.4	0.29	2.4
Sol. Ortho-P	0.43	0.077	0.13	0.038	0.125	0.074	0.057
Total P	0.55	0.43	0.225	0.215	0.21	0.21	0.21
			W-117 Logansport, Indiana				
Nitrate N	1.5	4.2	3.4	5.7	3.8	0.63	2.1
Sol. Ortho-P	0.26	0.081	0.21	0.095	0.15	0.042	0.042
Total P	0.30	0.37	0.26	0.20	0.21	0.092	0.14

Table 7 - Nitrogen and Phosphorus Data, Wabash River (Cont'd)

Mg/l	1967 Nov.	Dec.	1968 Feb.	Mar.	Apr.	May	June
			W-99 Lafayette, Indiana				
Nitrate N	0.70	4.5	3.5	5.3	3.9	1.05	3.0
Sol. Ortho-P	0.040	0.075	0.26	0.075	0.079	0.042	0.030
Total P.	0.074	0.28	0.325	0.14	0.15	0.10	0.14
			W-95 S.W. of Lafayette, Indiana				
Nitrate N	1.2	--	3.5	4.4	3.9	0.96	2.9
Sol. Ortho-P	0.12	--	0.31	0.078	0.077	0.070	0.051
Total P	0.20	--	0.38	0.145	0.17	0.15	0.18
			W-89 Attica, Indiana				
Nitrate N	1.1	4.4	3.6	4.6	3.7	0.79	2.7
Sol. Ortho-P	0.16	0.11	0.091	0.083	0.092	0.086	0.054
Total P.	0.29	0.42	0.13	0.15	0.18	0.20	0.18
			W-79 Cayuga, Indiana				
Nitrate N	1.1	4.5	4.2	5.1	4.2	1.45	3.6
Sol. Ortho-P	0.11	0.085	0.11	0.10	0.11	0.14	0.079
Total P.	0.17	0.33	0.205	0.20	0.18	--	0.20
			W-71 Clinton, Indiana				
Nitrate N	1.4	4.4	4.1	4.9	4.1	1.1	4.4
Sol. Ortho-P	0.14	0.077	0.083	0.090	0.10	0.076	0.069
Total P.	0.22	0.38	0.20	0.17	0.18	0.22	0.19
			W-61 Terre Haute, Indiana				
Nitrate N	0.95	4.3	--	5.0	4.0	1.1	4.1
Sol. Ortho-P	0.11	0.075	0.10	0.078	0.083	0.079	0.060
Total P.	0.19	0.40	--	0.18	0.18	0.19	0.18
			W-45 Merom, Indiana				
Nitrate N	1.3	4.1	--	3.3	0.78	1.0	4.3
Sol. Ortho-P	0.15	0.072	0.087	0.050	0.044	0.047	0.074
Total P.	0.23	0.21	--	0.16	0.24	0.28	0.23
			W-33 Vincennes, Indiana				
Nitrate N	1.3	--	3.8	4.6	4.0	1.0	4.4
Sol. Ortho-P	0.10	0.063	0.051	0.069	0.074	0.061	0.10
Total P.	0.19	--	0.19	0.19	0.15	0.19	0.22

Table V - Nitrogen and Phosphorus Data, Wabash River (Cont'd)

Month	1967 Nov.	Dec.	1968 Feb.	Mar.	Apr.	May	June
			W-19	Mt. Carmel, Illinois			
Nitrate N	1.0	--	4.0	3.3	3.2	0.76	2.6
Sol. Ortho-P	0.096	0.075	0.050	0.067	0.071	0.064	0.048
Total P.	0.22	--	0.13	0.24	0.20	0.20	0.22
			W-10	New Harmony, Indiana			
Nitrate N	1.0	3.9	2.6	3.0	2.8	0.86	3.0
Sol. Ortho-P	0.16	0.065	0.072	0.060	0.068	0.048	0.075
Total P.	0.31	0.26	0.20	0.19	0.20	0.14	0.22

Table 8 - Algae Composition near the mouth of Wildcat Creek, a tributary of the Wabash River

Algae, Number/ml	1968			
	Mar.	Apr.	May	June
Coccoid Green				
Ankistrodesmus sp.				409
Scenedesmus sp.				1924
Micractinium sp.				292
Chlorella sp.			1001	292
Oocystis sp.				117
Flagellates				
Chlamydomonas sp.				11,952
Euglena sp.		29		464
Chrysococcus sp.	343			58
Cryptomonas sp.		29	200	
Pandorina sp.			29	
Trachelomonas sp.	29			
Centric Diatoms				
Cyclotella sp.	15,215	1516	2317	2392
Melosira sp.		172		3673
Pennate Diatoms				
Synedra sp.	29	29	29	700
Navicula sp.		86	286	232
Surirella sp.	372	57	29	
Nitzschia sp.	114	172	257	17,898
Gomphonema sp.	515	29		
Cymbella sp.				117
Total	17,217	2,119	4,142	40,520

Table 9 - Algae Composition near the Mouth of Deer Creek, a Tributary of the Wabash River

Algae, Number/ml	1969			
	Mar.	Apr.	May	June
Coccoid Green				
Micractinium sp.			29	
Scenedesmus sp.				86
Oocystis sp.				29
Chlorella sp.				172
Ankistrodesmus sp.				29
Coelastrum sp.				29
Flagellates				
Euglena sp.		86		58
Chlamydomonas sp.		29	286	290
Cryptomonas sp.		57	114	
Chrysococcus sp.			86	86
Centric Diatoms				
Cyclotella sp.	744	8694	1459	1479
Stephanodiscus sp.	117			
Melosira sp.				348
Pennate Diatoms				
Surirella sp.	3260	29	57	29
Gomphonema sp.	915	57		
Nitzschia sp.	1144	515	715	1653
Synedra sp.	114	372	400	348
Rhoicosphenia curvata	114			
Meridian sp.	114			
Cymbella sp.	57	57		117
Navicula sp.	286	372	486	783
Diatoma sp.				58
Fragilaria sp.				117
Total	6,865	10,325	3,632	5,711

Table 10- Algae Composition near the Mouth of the Mississinewa River, a Tributary of the Wabash River

Algae, Number/ml	1968			
	Mar.	Apr.	May	June
Filamentous Blue-Green				
Schizothrix calcicola		458		406
Oscillatoria sp.				86
Coccoid Green		57		406
Scenedesmus sp.			1001	
Micractinium sp.				29
Crucigenia sp.				
Flagellates				
Chrysococcus sp.	86	172		29
Cryptomonas sp.			200	29
Pandorina sp.			29	
Euglena sp.				145
Centric Diatoms				
Cyclotella sp.	86	458	2317	232
Pennate Diatoms				
Surirella sp.	1516	343	29	27
Nitzschia sp.	86	143	257	580
Rhoicosphenia curvata	29			
Cymbella sp.	29			
Navicula sp.	29	257	286	1276
Gomphonema sp.	286	29		58
Synedra sp.		200	29	86
Cymatopleura solea				86
Total	1,947	2,117	4,148	3,475

Table 11 - Algae Composition near the Mouth of the Salamonie River, a Tributary of the Wabash River

Algae, Number/ml	1968			
	Mar.	Apr.	May	June
Flagellates				
Euglena sp.	29			29
Chrysococcus sp.	458	372		
Chlamydomonas sp.		57	29	29
Trachelomonas sp.		86		29
Centric Diatoms				
Cyclotella sp.	116	1516	1115	58
Melosira sp.	57	57	257	29
Pennate Diatoms				
Navicula sp.		200	86	116
Cymbella sp.			29	116
Rhoicosphenia curvata		57		58
Diatoms sp.			29	232
Gomphonema sp.	86			87
Nitzschia sp.	172	143	229	58
Surirella sp.	29	229	57	
Synedra sp.			86	
Total	947	2,717	1,917	841

Table 12 - Algae Composition Near Mouth of the Tippecanoe River, a Tributary of the Wabash River

Algae, Number/ml	1968			
	Mar.	Apr.	May	June
Coccoid Blue-Green				
Anacystis sp.				117
Chroococcus sp.				58
Filamentous Blue-Green				
Schizothrix calcicola		486	515	6821
Aphanizomenon sp.				525
Oscillatoria sp.				117
Anabaena sp.				292
Coccoid Green				
Micractinium sp.		143	57	
Scenedesmus sp.		200	172	583
Dictyosphaerium sp.		29		
Tetrastrum sp.		29		
Ankistrodesmus sp.		29		172
Chlorella sp.			57	467
Crucigenia sp.			29	
Actinastrum sp.			29	
Lagerheimia sp.			29	
Oocystis sp.			29	
Selenastrum sp.				117
Coelastrum sp.				58
Desmids				
Staurastrum sp.	29			
Flagellates				
Chlamydomonas sp.		114	114	525
Cryptomonas sp.		29	29	
Chrysococcus sp.		629	86	117
Euglena sp.			57	292
Dinobryon sp.			86	875
Trachelomonas sp.				58
Gonium sp.				58
Centric Diatoms				
Cyclotella sp.	8008	5463	2517	350
Melosira sp.	429	200	229	58
Pennate Diatoms				
Nitzschia sp.	858	458	172	58
Navicula sp.	715	57		
Surirella sp.	257	114		
Rhoicosphenia curvata	200		114	232
Gomphonema sp.	400		57	
Asterionella sp.	286	1516	2230	350
Synedra sp.		372	601	175
Diatoma sp.			57	58
Total	11,182	9,868	7,266	12,591

Table 13 - Algae Composition near the Mouth of the Eel River, a Tributary of the Wabash River

Algae, Number/ml	1968 Mar.	Apr.	May	June
Filamentous Blue Green				
Schizothrix calcicola				700
Lyngbia sp.				172
Oscillatoria sp.				117
Anabaena sp.				172
Coccoid Green				
Tetrastrum sp.	29		29	
Actinastrum sp.			86	292
Scenedesmus sp.			29	1341
Coelastrum sp.			29	292
Micractinium sp.				117
Tetraedron sp.				58
Ankistrodesmus sp.				172
Dictyosphaerium sp.				172
Lagerheimia sp.				58
Oocystis sp.				117
Chlorella sp.				2624
Desmids				
Closterium sp.				117
Flagellates				
Chlamydomonas sp.		86	86	3333
Cryptomonas sp.		29		232
Euglena sp.		29	29	172
Trachelomonas sp.				58
Gonium sp.				58
Chrysococcus sp.	57	200	200	232
Dinobryon sp.		57		
Centric Diatoms				
Cyclotella sp.	86	4004	15,272	1224
				117
Pennate Diatoms				
Navicula sp.	172	57	86	117
Surirella sp.	572	29	29	
Gomphonema sp.	343	57		
S[illegible]ra sp.	29	172	1144	172
Ni[illegible]hia sp.	200	286	829	3272
Meri[illegible] sp.		29		
Asterionella sp.		57		
Rhoicosphenia curvata		29	29	
Total	1,488	5,121	17,877	15,508

Summary of Chemical Data - [illegible] River, Indiana and Grand Lake, Ohio

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Sta. No.	Station Description		Nitrate Nitrogen, Total (mg/l as N)	Nitrite Nitrogen, Total (mg/l as N)	Total Kjeldahl Nitrogen (mg/l as N)	Total Phosphorus (mg/l as P)	Ortho-phosphate, Dissolved (mg/l as P)	Chemical Oxygen Demand (mg/l)	Dissolved Oxygen, Total (mg/l)	Field Alkalinity (mg/l)	Water Temp. (°C)	Field pH	Field Cond. (µmhos/cm @ 25°C)	Turb. (J.T.U.)
	Grand Lake													
G-151	Celina, Ohio	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Beaver Creek													
G-149	Near Wabash, Ohio	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Wabash River													
G-150	Ind. - Ohio State Line	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Wabash River													
G-151	Bluffton, Ind.	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Wabash River													
G-140	Huntington, Ind.	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	0.13	0.000	1.4	.07	0.111	0.111	51.0	16.3	11.2	8.1	-	504	47
	Wabash River													
G-131	Wabash, Ind.	Max.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Min.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Sta. No.	Station		Nitrate Nitrogen, Total (mg/l as N)	Phosphorus, Total (mg/l as P)	Phosphorus, Dissolved (mg/l as P)	Solids, Residue at 180°C, Dissolved (mg/l)	Susp. Solids (mg/l)	Fixed Solids, Dissolved (mg/l)	Field DO (mg/l)	Water Temp. °C.	Field pH	Field Cond. (micromhos)	Turb. (J.U.)
	Wabash River												
W-12	Peru, Ind.	Max.	.31	.23	.4	.05	.04	.03	400	400	13.5	24	8.0	650	350
		Min.	.1	.1	.1	.1	.1	.001	20	0	4.0	0	5.8	340	11
		Avg.	.19	.11	--	.07	.07	.014	94.	1.	10.4	9.1	--	419	103
	Wabash River												
W-11	Terre Haute, Ind.	Max.	.3	.2	.4	.1	.1	.05	72	49	14.5	28	8.4	800	400
		Min.	.1	.01	.1	.01	.01	.004	10	1	10.5	0	6.5	470	5
		Avg.	.21	.061	--	.04	.1	0.01	76.0	17.4	12.8	12.0	--	604	77
	Wabash River												
W-10	Lafayette, Ind.	Max.	.5	.17	1.1	0.2	.1	.1	150	30	14.6	28	7.9	675	160
		Min.	.07	.07	.2	0.004	.004	.000	3	1	8.5	7	6.8	420	8
		Avg.	.14	.063	--	0.17	.1	0.03	94.	7.67	11.2	12.0	--	577	39
	Wabash River												
W-9	10 Mi. S. of Lafayette, Ind.	Max.	.4	0.	.3	.1	.1	.1	1	0	14.2	28	7.9	700	22
		Min.	.1	.1	.1	0.01	0.01	0.01	17	0	7.8	0	6.5	550	11
		Avg.	.2	0.09	--	0.03	0.8	0.12	54.3	--	10.4	11.1	--	612	20
	Wabash River												
W-8	Attica, Ind.	Max.	.4	.2	1.1	0.4	.1	0.1	140	0	12.4	26	8.4	800	43
		Min.	0.74	.04	.1	0.13	0.01	0.004	11	2	8.9	0	6.6	390	10
		Avg.	.2	.11	--	0.2	0.1	0.0*	68.0	11.0	10.3	10.7	--	595	14
	Wabash River												
W-7	Covington, Ind.	Max.	0.1	0.3	1.2	0.1	.1	0.14	130	32	12.9	30	8.4	740	250
		Min.	1.1	0.06	1.1	0.17	.06	0.079	7	1	8.0	0	6.4	380	12
		Avg.	.46	0.1	--	0.2	0.11	0.104	49.0	8.8	10.8	10.1	--	550	50

Summary of Chemical Data - Wabash River, Indiana and Grand Lake, Ohio

Table 14 (Cont'd)
October 1 Thru June 1

Sta. No.	Station Description		Nitrate Nitrogen mg/l	Ammonia Nitrogen mg/l	Total Kjeldahl Nitrogen mg/l	Total Phos. mg/l	Total Phosphate mg/l	Soluble Orthophosphate mg/l	Alk. Calcium mg/l	Hard. Mag. Calcium mg/l	Field pH	Water Temp. °C	Field pH	Field Conductivity	Turb. FTU
	Wabash River														
W-71	Clinton, Ind.	Max.	4.9	0.09	1.4	0.	.1	.14	150	9	12.0	25	8.2	750	130
		Min.	1.1	0.00	0.	0.17	0.03	.08	14	0	6.4	0	7.0	190	14
		Avg.	3.5	0.035	1.0	0.07	0.11	.04	74.0	1.0	9.65	10.1	--	532	52
W-1	Wabash River Terre Haute, Ind.	Max.	5.0	0.50	2.7	0.40	0.1	0.11	250	36	12.5	27	8.3	800	200
		Min.	2.00	0.00	1.1	0.10	0.071	0.060	9	1	6.2	0	7.0	380	10
		Avg.	3.70	0.14	1.4	0.24	0.09	0.075	99.5	9.25	10.0	11	--	579	68
W-49	Wabash River Merom, Ind.	Max.	4.	0.10	4.0	0.20	0.1	0.10	95	9	10.5	27	7.9	775	100
		Min.	0.75	0.04	1.0	0.10	0.045	0.027	18	1	9.1	0	6.2	430	14
		Avg.	2.3	--	2.7	0.21	0.09	0.060	46.0	4.7	10.1	11.3	--	537	51
W-32	Wabash River Vincennes, Ind.	Max.	4.7	0.10	4.0	0.20	0.11	0.10	85	9	12.5	28	8.3	775	79
		Min.	1.0	0.04	1.	0.10	0.060	0.045	9	1	9.3	0	7.4	470	23
		Avg.	2.7	--	2.0	0.14	0.07	0.07	52.1	5	10.8	11.3	--	561	38
W-10	Wabash River Mt. Carmel, Illinois	Max.	4.7	0.10	5.	0.2	0.1	0.10	140	16	13.0	29	8.1	760	140
		Min.	0.70	0.04	0.4	0.20	0.060	0.050	42	1	9.1	0	7.0	390	25
		Avg.	2.7	0.13	1.8	0.24	0.07	0.060	74.1	11.75	11.0	10.8	--	492	62
W-10	Wabash River New Harmony, Indiana	Max.	4.9	0.10	5.2	0.21	0.17	0.10	140	19	13.0	29	8.1	750	140
		Min.	0.90	0.01	1.1	0.14	0.062	0.040	15	1	9.2	0	7.0	430	20
		Avg.	2.45	0.07	--	0.20	0.08	0.070	90.0	10.5	11.0	10.0	--	518	59

Chemical Data - Grand River, Indiana and Grand Lake, Ohio

Table 15

Sta. No.	Station Description and Sample Date	Nitrate Nitrogen Mg/l	Ammonia Nitrogen Mg/l	Total Kjel. Nitrogen Mg/l	Total Phos. Mg/l	Total Soluble PO4 Mg/l	Soluble Ortho-PhosP Mg/l	Susp. Solids Mg/l	Susp. Vol. Solids Mg/l	Field DO Mg/l	Water Temp. °C.	Field pH	Field Cond. Micromhos	Turb. J.T.U.
	Grand Lake													
W-1	**Celina, Ohio**													
	November 1, 1967	--	--	--	0.14	--	--	--	--	--	--	--	--	--
	December 27, 1967	1.5	--	--	0.1	0.060	0.047	8	8	11.0	7	7.6	450	44
	February 19, 1968	1.25	0.4	1.4	0.51	0.41	0.40	34	21	13.0	0	6.8	425	11
	March 27, 1968	1.5	0.44	1.1	0.17	0.13	0.078	44	6	11.5	10	6.5	350	56
	April 17, 1968	0.78	0.095	1.5	0.19	0.095	0.017	40	35	10.0	11	7.6	280	40
	May 9, 1968	0.23	--	0.4	0.03	0.1	0.10	--	--	9.5	15	7.9	385	45
	June 12, 1968	0.1	0.07	0.6	0.17	0.10	0.08	--	--	9.5	20	7.7	320	27
	Beaver Creek													
W-157	**Near Wabash, Ohio**													
	November 1, 1967	4.4	--	6.1	3.0	2.0	1.4	29	5	10.5	1	6.9	1500	34
	December 27, 1967	1.9	--	4.9	0.20	0.14	0.087	41	6	12.0	0	7.6	440	61
	February 19, 1968	1.25	0.69	2.4	0.38	0.16	0.15	26	18	13.6	0	6.7	425	--
	March 27, 1968	0.7	0.8	3.9	0.60	0.20	0.14	100	4	9.0	8	7.7	360	95
	April 18, 1968	2.5	1.4	5.9	1.7	0.50	0.48	56	--	8.5	10	7.6	620	48
	May 9, 1968	1.4	--	4.3	1.5	--	1.36	--	--	6.0	14	7.2	1400	23
	June 12, 1968	0.2	0.68	6.7	1.7	1.36	0.99	--	--	5.0	23	7.2	810	63
	Wabash River													
W-155	**Ind - Ohio State Line**													
	November 1, 1967	0.4	--	0.4	0.22	0.20	0.21	13	7	11.5	1	7.3	1025	35
	December 27, 1967	2.1	--	0.9	0.26	0.13	0.12	78	54	11.0	0	7.6	520	61
	February 20, 1968	1.4	0.76	--	0.27	0.18	0.17	34	25	12.5	0	6.1	500	17
	March 29, 1968	7.0	0.4	1.2	0.43	0.15	0.14	10	14	11.0	8	7.6	350	40
	April 17, 1968	3.0	0.34	1.2	0.33	0.19	0.19	43	--	9.0	12	7.6	860	30
	May 9, 1968	0.81	--	1.1	0.18	--	0.345	--	--	9.0	15	7.3	1275	19
	June 12, 1968	1.9	0.11	2.2	0.33	0.12	0.11	--	--	6.0	24	7.1	800	50

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Grand Lake, Ohio

Sta. No.	Station Description and Sample Date	Nitrate Nitrogen mg/l	Ammonia Nitrogen mg/l	Total Kjeldahl Nitrogen mg/l	Total P mg/l	Total Soluble Phosphate mg/l	Soluble Orthophosphate mg/l	Susp. Solids mg/l	Susp. Vol. Solids mg/l	Field pH pH Units	Water Temp. °C	Field DO mg/l	Field Conductance µmhos/cm	Turb. JTU
	Wabash River													
10-1	Peru, Indiana													
	November 17, 1977	1.2	--	1.0	0.10	0.04	0.01	14	8	11.5	2	7.4	700	12
	December , 1977	0.90	--	-	0.11	0.03	0.02	10	6	12.5	0	8.0	740	900
	February 20, 1978	0.84	0.24	--	0.08	0.11	0.07	18	9	11.7	3	7.5	610	43
	March 20, 1978	0.64	0.13	--	0.11	0.10	0.067	16	10	10.8	7	7.5	510	57
	April 10, 1978	0.54	0.10	--	0.11	--	0.13	34	--	9.5	10	7.5	725	34
	May 7, 1978	0.24	0.07	0.9	0.11	--	0.074	--	--	10.0	17	7.1	650	11
	June 11, 1978	0.4	0.15	--	0.11	--	0.07	--	--	10.5	28	8.0	740	10
	Wabash River													
10-11	Lowensport, Indiana													
	November 17, 1977	1.0	--	1.0	0.10	0.07	0.01	11	4	11.5	5	7.5	700	17
	December 21, 1977	0.90	--	--	0.13	0.060	0.031	73	4	11.5	0	8.0	620	400
	February 20, 1978	0.84	0.24	--	0.08	0.11	0.1	20	11	11.1	3	7.6	610	35
	March 20, 1978	0.7	0.11	--	0.10	0.11	0.070	16	14	11.0	7	7.5	540	47
	April 10, 1978	0.5	0.08	--	0.11	--	0.11	14	--	10.5	14	8.4	700	19
	May 7, 1978	0.23	0.07	--	0.098	--	0.063	--	--	10.7	19	7.1	700	5
	June 11, 1978	0.1	0.04	--	0.10	--	0.06	--	--	14.5	28	7.6	650	25
	Wabash River													
10-1	Lafayette, Indiana													
	November 17, 1977	0.70	--	0.9	0.14	0.06	0.03	9	4	11.5	6	7.9	675	14
	December 20, 1977	0.8	--	--	0.21	0.080	0.077	150	70	13.0	0	7.7	400	170
	February 20, 1978	0.6	0.17	--	0.17	0.1	0.1	14	1	14.4	3	7.9	470	28
	March 20, 1978	0.7	0.9	--	0.14	0.094	0.075	19	--	10.5	8	7.1	700	24
	April 10, 1978	0.9	0.20	--	0.13	--	0.079	79	--	9.5	14	7.6	600	29
	May 7, 1978	1.00	0.09	1.1	0.13	--	0.080	--	--	10.3	19	7.3	600	10
	June 11, 1978	2.0	0.09	--	0.14	--	0.060	--	--	11.0	28	7.2	675	19

Sta No	Station Description and Sampling Date	Nitrate Nitrogen Mg/l	Ammonia Nitrogen Mg/l	Total Kjel Nitrogen Mg/l	Total Phos Mg/l	Total Soluble Phos Mg/l	Soluble Ortho-Phos Mg/l	Susp. Solids Mg/l	Susp. Vol Solids Mg/l	Field DO Mg/l	Water Temp. C	Field pH	Field Cond. µMHOS	Turb. JTU
W-58	Wabash River - Ind. Line, Ind.													
	November 17, 1977	1.2	--	0.9	0.13	0.11	0.1	17	4	10.5	5	7.9	700	14
	December 28, 1977	--	--	--	--	--	--	--	--	--	--	--	--	--
	February 20, 1978	3.5	0.10	--	0.2	0.2	0.1	17	--	12.5	0	6.5	590	23
	March 28, 1978	4.4	0.10	--	0.14	0.04	0.03	20	7	9.0	8	7.9	650	18
	April 18, 1978	3.9	0.08	--	0.17	--	0.07	31	--	7.5	11	7.1	550	23
	May 7, 1978	0.8	0.3	0.9	0.2	--	0.09	--	--	9.0	15	7.2	590	11
	June 11, 1978	2.9	0.04	--	0.10	--	0.051	--	--	14.0	28	7.6	590	17
W-59	Wabash River Attica, Indiana													
	November 17, 1977	1.1	--	1.1	0.14	0.1	0.10	11	3	9.0	5	7.8	500	1
	December 28, 1977	4.4	--	--	0.24	0.1	0.11	60	10	12.5	0	8.1	590	--
	February 20, 1978	3.6	0.03	--	0.13	0.07	0.04	1	--	12.5	1	6.9	430	23
	March 28, 1978	5.0	0.11	--	0.15	0.095	0.060	10	7	--	--	--	--	17
	April 18, 1978	4.0	0.04	--	0.1	--	0.09	15	--	9.5	15	8.1	570	14
	May 7, 1978	0.79	0.09	0.9	0.09	--	0.04	--	--	9.0	17	8.4	440	10
	June 11, 1978	2.7	0.10	--	0.13	--	0.056	--	--	--	26	8.0	490	17
W-79	Wabash River Centre, Indiana													
	November 17, 1977	1.1	--	1.3	0.17	0.10	0.11	4	1	10.0	5	7.9	540	12
	December 28, 1977	4.4	--	--	0.27	0.091	0.085	150	23	12.5	0	7.9	590	200
	February 20, 1978	4.2	0.05	--	0.20	0.10	0.11	30	4	13.4	0	7.4	500	30
	March 28, 1978	5.1	0.15	--	0.20	0.10	0.10	15	8	--	--	--	--	20
	April 18, 1978	4.2	0.08	--	0.13	--	0.11	18	--	10.3	14	8.1	540	27
	May 7, 1978	1.40	0.13	1.3	--	--	0.14	--	--	9.0	18	8.2	500	37
	June 11, 1978	1.6	0.06	--	0.20	--	0.079	--	--	--	26	7.9	540	19

Chemical Data - Wabash River, Indiana and Grand Lake, Ohio

Table 15 (Contd)

Site No.	Station Description and Sampling Date	Nitrate Nitrogen Mg/l	Ammonia Nitrogen Mg/l	Total Kjel. Nitrogen Mg/l	Total Phos. Mg/l	Total Soluble Phos. Mg/l	Soluble Ortho-Phos. Mg/l	Fecal Coliform No/100ml	Susp. Vol. Solids Mg/l	Field DO Mg/l	Water Temp °C	Field pH	Field Cond. umhos/cm	Turb. JTU
W-1	Wabash River Clinton, Indiana													
	November 17, 19[illegible]	1.4	--	1.0	0.2	0.1	0.04	1		10.0	5	7.8	750	14
	December [illegible], 19[illegible]	3.4	--	--	--	0.09	0.04	80	9	12.0	0	8.0	890	14
	January [illegible], 19[illegible]	4.1	--	1.0	0.2	0.07	0.03	100	7	--	0	--	--	42
	March [illegible], 19[illegible]	4.4	0.04	--	0.2	0.10	0.04	60	9	--	--	--	--	9
	April 1[illegible], 19[illegible]	4.1	0.04	1.1	0.1	--	0.03	20	--	9.4	14	8.0	640	20
	May [illegible], 19[illegible]	1.1	0.05	1.4	0.20	--	0.09	--	--	8.4	19	8.1	470	9
	June 11, 19[illegible]	4.4	0.06	--	0.10	--	0.04	--	--	--	23	7.8	500	10
W-1	Wabash River Terre Haute, Indiana													
	November [illegible], 19[illegible]	0.8	--	1.0	0.13	0.1	0.11	11	5	11.0	4	7.8	430	12
	December [illegible], 19[illegible]	4.1	--	--	0.07	0.001	0.000	60	--	12.0	0	8.1	890	10
	March 7, 19[illegible]	3.1	0.1	1.0	0.1	0.11	0.1	4	1	--	0	--	--	11
	March 25, 19[illegible]	3.0	0.10	--	0.1	0.04	0.000	10	7	--	--	--	--	22
	April 15, 19[illegible]	4.0	0.06	1.0	0.13	--	0.001	4	--	9.7	14	8.4	380	13
	May 9, 19[illegible]	1.1	0.13	1.2	0.13	--	0.040	--	--	9.0	19	8.1	490	20
	May 31, 19[illegible]	4.3	0.00	1.0	0.1	--	0.003	50	--	--	--	--	--	220
	June 11, 19[illegible]	4.1	0.17	1.0	0.13	--	0.040	--	--	--	27	7.7	450	14
W-[illegible]	Wabash River Mouth, Indiana													
	November [illegible], 19[illegible]	1.1	--	1.0	0.1	0.10	0.15	24	4	11.0	8	7.7	77	14
	January [illegible], 19[illegible]	4.1	--	--	0.03	0.01	0.01	24	--	13.0	0	7.9	490	10
	March [illegible], 19[illegible]	3.1	0.15	--	0.1	0.04	0.03	17	1.7	--	5	--	--	4
	March 25, 19[illegible]	4.1	0.1	--	0.1	0.00	0.00	40	7	--	--	--	--	24
	April 13, 19[illegible]	0.00	0.04	--	0.04	--	0.04	20	--	10.4	19	7.8	430	23
	May 10, 19[illegible]	1.0	0.04	1.0	0.1	--	0.04	--	--	9.0	19	7.8	490	100
	June 10, 19[illegible]	4.1	--	--	0.00	--	0.04	--	--	--	27	7.7	470	45

Map No.	Station Description and Type of Sample	Nitrate Nitrogen, Total (mg/l as N)	Ammonia Nitrogen, Total (mg/l as N)	Total Kjeldahl Nitrogen, Total (mg/l as N)	Total Phosphorus, Total (mg/l as P)	Total Soluble Phosphate (mg/l as PO4)	Soluble Orthophosphate (mg/l as PO4)	Turbidity (JTU)	Specific Conductance (micromhos/cm)	Dissolved Oxygen, Field (mg/l)	Water Temperature (°C)	Field pH	Field Specific Conductance (micromhos/cm)	Fecal Coliform, MF (col/100 ml)
	Wabash River Vincennes, Indiana													
	November 25, 1975	1.0	--	1.0	0.13	0.11	0.1	11	1	11.0	7	7.9	770	11
	January 6, 1976	0.9	--	--	0.07	0.06	0.05		1	12.5	0	7.6	470	94
	February 10, 1976	0.8	--	--	0.14	0.09	0.01	7	4	--	--	--	--	55
	March 9, 1976	0.7	0.11	--	0.10	0.06	0.04	8	--	--	8	--	--	17
	April 13, 1976	0.8	0.05	--	0.10	0.06	0.04	7	--	--	--	--	--	28
	May 10, 1976	1.0	0.06	0.9	0.13	--	0.054	8	--	8.4	18	7.9	560	27
	June 15, 1976	0.4	0.11	--	0.10	--	0.061	--	--	9.0	19	8.1	480	25
	Wabash River Mt. Carmel, Illinois													
	November 26, 1975	1.0	--	1.0	0.09	0.07	0.04	40	1	11.0	7	7.9	760	32
	January 8, 1976	0.9	--	--	0.07	0.06	0.05	100	1	13.0	0	7.9	500	140
	February 10, 1976	0.8	--	1.4	0.11	0.07	0.060	60	7	--	--	--	--	52
	March 9, 1976	0.8	0.10	--	0.10	0.11	0.10	60	10	--	8	--	--	25
	March 24, 1976	0.8	0.11	0.9	0.08	0.060	0.047	100	14	--	--	--	--	33
	April 13, 1976	0.8	0.07	1.4	0.09	--	0.071	7	--	10.0	13	8.0	410	55
	May 10, 1976	0.7	0.09	0.8	0.09	--	0.054	--	--	9.1	18	8.1	480	30
	June 12, 1976	0.5	0.07	1.0	0.09	--	0.060	--	--	--	25	7.7	440	40
	Wabash River New Harmony, Indiana													
	November 24, 1975	1.0	--	1.3	0.11	0.11	0.1	--	10	12.5	7	8.0	770	34
	January 7, 1976	0.9	--	--	0.07	0.07	0.06	140	1	13.5	0	7.8	430	140
	March 8, 1976	0.8	0.10	--	0.10	0.07	0.072	15	1	--	0	--	--	70
	March 27, 1976	0.8	0.10	--	0.11	0.060	0.060	60	19	--	--	--	--	70
	April 13, 1976	0.8	0.06	--	0.10	--	0.068	--	--	11.0	15	8.1	450	50
	May 10, 1976	0.9	0.05	1.0	0.14	--	0.061	--	--	9.0	18	8.1	500	27
	June 12, 1976	1.0	0.09	--	0.10	--	0.075	--	--	--	25	7.8	450	40

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Chemical Data for Tributaries to [illegible]

Grand River and Grand Lake, Ohio

Site No.	Station Description and Date	Nitrate Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Soluble Phosphorus (mg/L)	Soluble Orthophosphorus (mg/L)	Chloride (mg/L)	Field pH (S.U.)	Water Temp. (°C)	Field pH (S.U.)	Field Cond. (µmhos/cm)	Tur (JTU)
	Sample Water												
	Chrisman Creek												
CT-1	Trib. to Grand Lake												
	January 9, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.0	[illegible]	[illegible]	760	--
	February 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.0	1.0	[illegible]	1000	15
	March 27, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1	570	42
	April 17, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.0	10	[illegible]	480	25
	May [illegible], 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.0	15	7.1	900	11
	June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.3	800	17
	Prairie Creek												
CT-2	Trib. to Grand Lake												
	January 30, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74	--
	February 14, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.5	[illegible]	[illegible]	580	21
	March 27, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1	600	47
	April 17, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	[illegible]	490	23
	May [illegible], 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.5	17	8.1	800	7
	June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.1	16	7.2	950	50
	Beaver Creek												
CT-3	Trib. to Grand Lake												
	January 30, 19[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.5	[illegible]	[illegible]	475	--
	February 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	640	13
	March 27, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	525	24
	April 17, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	--	55
	May [illegible], 19[illegible]	[illegible]	--	--	[illegible]	--	[illegible]	[illegible]	15.0	16	7.9	590	2
	June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	525	[illegible]

Chemical Data for Tributaries to Table 16 (Part 1) Page 2 of Table 16

Wabash River and Grand Lake, Ohio

Site No.	Station Description and Sampling Date	Nitrate Nitrogen mg/l	Ammonia Nitrogen mg/l	Total Kjel. Nitrogen mg/l	Total Nitrogen mg/l	Total Soluble Phos. mg/l	Soluble Ortho-Phosphate mg/l	Chlorides mg/l	Field DO mg/l	Water Temp. °C	Field pH	Field Cond. Umhos/cm	Turb. J.T.U.
	Coldwater Creek												
CC-1	Trib. to Grand Lake												
	January 19, 1978	1.1	0.07	1.2	1.3	0.20	0.18	--	13.2	0	7.0	420	9
	March 17, 1978	0.3	0.17	--	0.71	0.04	0.04	15	8.5	11	7.2	425	25
	April 17, 1978	1.1	0.05	1.2	1.3	0.11	0.088	5	10.0	13	7.4	440	44
	May 8, 1978	0.1	--	1.0	1.1	--	0.15	21	10.0	15	7.5	560	73
	June 11, 1978	0.40	0.07	1.0	1.07	0.11	0.105	21	6.8	21	6.8	470	83
	Salamonie River												
SAL-1	Trib. to Wabash River												
	May 8, 1978	1.4	--	1.6	0.98	--	0.050	14	14.1	18	8.1	370	7
	June 11, 1978	4.0	0.04	2.20	3.04	--	0.034	14	8.0	17	7.6	430	17
SAL-2.0	Salamonie River												
	April 17, 1978	3.1	0.07	4.0	0.15	--	0.077	--	11.0	12	7.4	--	25
SAL-15	Salamonie River												
	April 18, 1978	1.1	0.47	--	1.45	--	0.29	18	10.0	15	7.4	700	40
	Tippecanoe River												
TIP-1	Trib. to Wabash River												
	April 17, 1978	--	--	--	0.1	--	0.070	14	10.5	14	8.2	600	13
	May 8, 1978	1.0	--	1.4	0.960	--	0.034	14	8.2	14	6.9	550	7
	June 11, 1978	0.1	0.09	--	0.057	--	0.044	14	7.0	17	7.0	600	19

[illegible] and [illegible] River and [illegible] Lake, [illegible]

[illegible] Description of Site and Sampling Date	Trash	Grease	Total Coli. Bacteria	Fecal Coli. Bacteria	Total Coliphage	Soluble Organic [illegible]	Flow-ing	Yield	Water	Yield	Yield	Yield
[illegible] Creek												
[illegible] Lake and River												
[illegible], 19[illegible]	--	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Deer River												
[illegible] [illegible] to Bad River												
[illegible], 19[illegible]	[illegible]	--	--	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Red River												
[illegible] [illegible] to Bad River												
[illegible], 19[illegible]	[illegible]	--	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June 11, 19[illegible]	--	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wapiti Creek												
[illegible] [illegible] to Bad River												
April 1, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible], 19[illegible]	[illegible]	--	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June 11, 19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Wapiti River												
[illegible] [illegible] to Bad River												
April 1, 19[illegible]	[illegible]	[illegible]	--	[illegible]	--	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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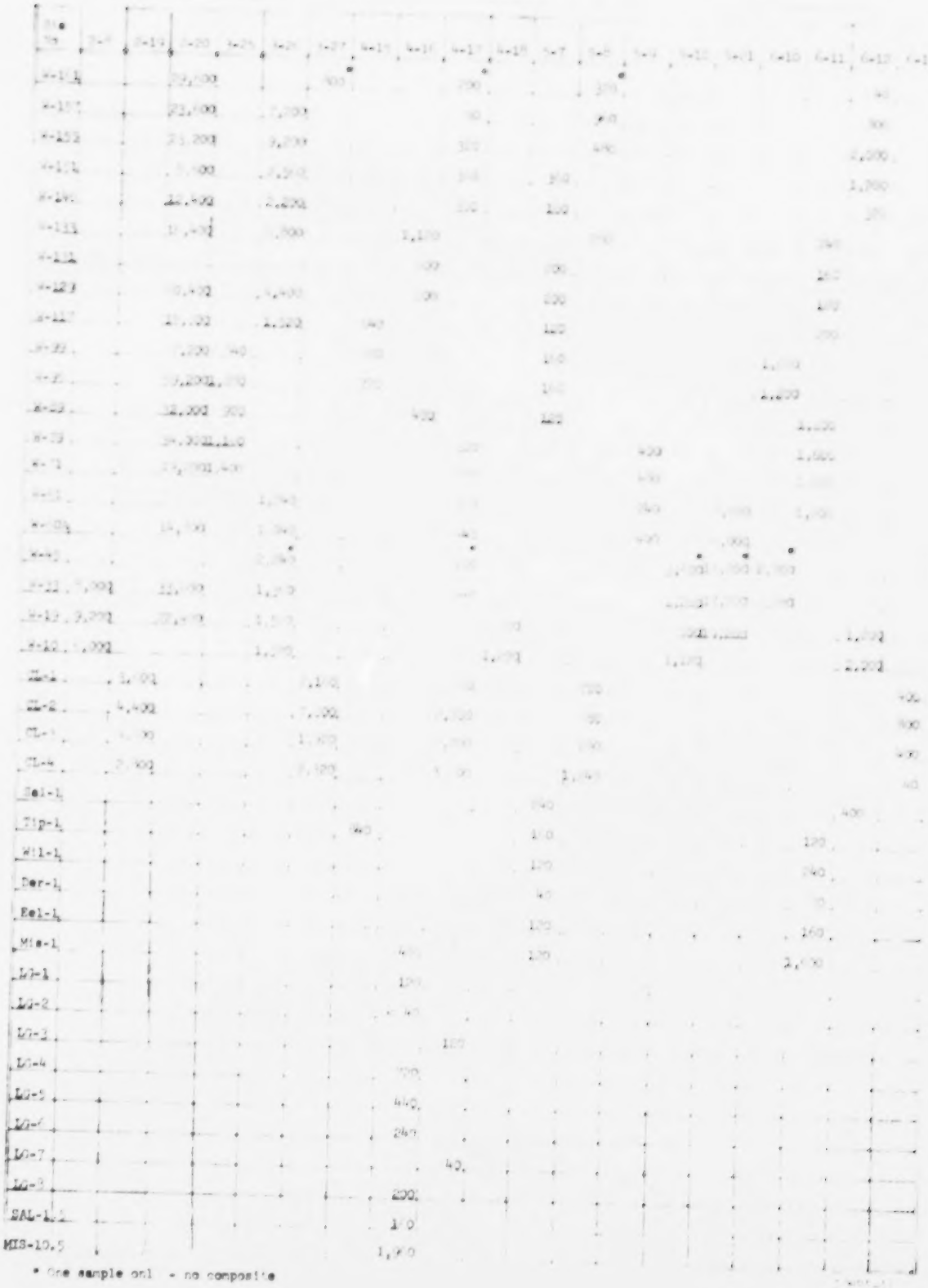
Flow data (cfs) wabash river, indiana and ohio, 1966 — Sheet 11 of Table 19

STA. (MILE)	Mar. 1	Mar. 7	Mar. 13	Mar. 19	Mar. 25	Mar. 31	Apr. 6	Apr. 12	Apr. 18	Apr. 24	May 30	May 6	May 12	May 18	May 24	May 30	June 5	June 11	June 17	June 23	June 29
-141																					
-137	(4,)	(,00)	(1,)	(,00)	(11,)	(10,)															
-133	1,00)	,00	4	,00	,00	,0															
-131	(1,00)	(1,00)	(,00)	(,00)	(,00)	(,00)															
-129	(,00)	(,00)	(,00)	(,00)	(,00)	(,00)															
-123	,00	,00	,0	,00	,00	,00															
-121	(,00)	(,00)	(,00)	(,00)	(,00)	(,00)															
-119	(,00)	(,00)	(1,000)	(1,00)	(1,00)	(,00)															
-117	,00	,00	,00	,00	,00	,00															
-11	(1,00)	(12,00)	(,00)	(,00)	(,00)	(,00)															
-9	(11,00)	(12,000)	(,00)	(,00)	(,00)	(,00)															
-93	(11,00)	(11,00)	(,00)	(,00)	(,00)	(,00)															
-91	(11,00)	(11,00)	(,00)	(,00)	(,00)	(,00)	7,00	(,00)													
-8 1	(11,00)	(11,00)	(11,00)	(11,00)	(,00)	(,00)												(12,000)	(,00)	(,00)	(7,00)
-8 1	(11,00)	(10,00)	(10,00)	(11,00)	11,00)	(11,00)	(,00)	(,00)										(12,00)	(,00)	(,00)	(,00)
-84	(11,00)	(11,00)	(11,00)	(11,00)	(12,00)	(11,00)															
-81	(11,00)	(10,00)	(11,00)	(11,00)	(1 ,00)	(1 ,00)															
-79	10,00	10,00	10,00	10,00	,00	,00															
-77	(10,00)	(11,00)	(,00)	(,00)	(,00)	(,00)															



* One sample only - no composite

Phytoplankton Data

Table 29

Wabash River, Indiana - Grand Lake, Ohio

November 1971

Sampling Date and Station No Algae - Number/ml	Nov 15 A-161	Nov 15 A-157	Nov 15 A-153	Nov 15 A-152	Nov 17 A-147	Nov 17 A-141	Nov 17 A-137	Nov 17 A-132	Nov 17 A-131	Nov 17 A-126	Nov 17 A-122	Nov 17 A-121	Nov 17 A-116	Nov 17 A-111	Nov 20 A-106	Nov 20 A-101	Nov 24 A-96	Nov 24 A-91
Coccoid Blue-Green Algae																		
Anacystis sp.	7,665	513																
Agmenellum sp.	342																	
Coelosphaerium sp.	171	114																
Coccochloris sp.	171	57		x														
Filamentous Blue-Green Algae																		
Schizothrix calcicola	43,174	2,451	114			171			741	1,254	684	342	627	627	513	770	570	171
Aphanizomenon sp.	1,539	456																
Oscillatoria sp.									57	1,254	1,140	456	342		114			
Coccoid Green Algae																		
Scenedesmus sp.	4,218	969		285	969	114	114	171	57	57	114	342	342	57	171	456	456	627
Selenastrum sp.	1,482																	
Tetraedron sp.	114																	
Coelastrum sp.	57													57				
Ankistrodesmus sp.	114			57	57			57	114	57	114	741	285	456		627	114	456
Pediastrum sp.	627			57	57			57							57			
Tetrastrum sp.	285			57	57													
Dictyosphaerium sp.	342								57	57	114	171	57	57	114	57	57	
Micractinium sp.	57										57							
Oocystis sp.		57													57			57
Schroederia sp.				57														
Lagerheimia sp.											57							
Crucigenia sp.												57	57	171	114	57		
Chlorella sp.														114			57	
Golenkinia sp.															57		513	342
Actinastrum sp.															57	114		
Desmids																		
Cosmarium sp.	456	57																
Staurastrum sp.	171																	
Closterium sp.	57																	
Flagellates																		
Chlamydomonas	285			57			228	456	57	456	228	342	456	342	114	342	285	228
Euglena sp.	57			57														
Cryptomonas sp.	801	120		342		1,197	570				57	57		57		57	57	
Carteria sp.				57		570	57	228			342	114	171	285	57	285	171	342
Phacus sp.				57														
Chrysococcus sp.				228	114	57	114	114	627	342	342	228	456	228	114	456	342	228
Mallomonas sp.					114	228												
Trachelomonas sp.											114	285	57	228		57	114	
Synuria sp.									57	57		57				57		
Peridinium sp.									57	57	342		342			57		
Dinobryon sp.						57			342									
									57									
Centric Diatoms																		
Cyclotella sp.				57	1,197	1,539	570	1,368	2,166	2,337	4,332	3,420	14,022	16,047	17,360	41,020	50,331	2,166
Melosira sp.	4,218	342				228			2,337	1,083	2,223	1,083	1,596	1,254	1,254	2,565	1,824	1,026
Stephanodiscus sp.									171									

Phytoplankton Data

Wabash River, Indiana - Grand Lake, Ohio

Sample Date and Station No Algae - Number/l																				
Pennate Diatoms																				
Nitzschia sp.																				
Synedra sp.																				
Navicula sp.																				
Surirella sp.																				
Cymbella sp.																				
Gyrosigma sp.																				
Diatoma sp.																				
Cymatella sp.																				
Asterionella sp.																				
Tabellaria sp.																				
Rhoicosphenia curvata																				
Total																				

Sampling Date and Station No. / Algae - Numerical																							
Coccoid Blue-Green Algae																							
Anacystis sp.																							
Gomphosphaeria sp.																							
Coccochloris sp.																							
Filamentous Blue-Green Algae																							
Schizothrix calcicola																							
Aphanizomenon sp.																							
Oscillatoria sp.																							
Coccoid Green Algae																							
Scenedesmus sp.																							
Selenastrum sp.																							
Tetraedron sp.																							
Coelastrum sp.																							
Ankistrodesmus sp.																							
Pediastrum sp.																							
Tetrastrum sp.																							
Dictyosphaerium sp.																							
Micractinium sp.																							
Oocystis sp.																							
Schroederia sp.																							
Lagerheimia sp.																							
Dictyosphaerium sp.																							
Actinastrum sp.																							
Oocystis sp.																							
Chlorella sp.																							
Golenkinia sp.																							
Desmids																							
Spondylosium sp.																							
Staurastrum sp.																							
Closterium sp.																							
Flagellates																							
Chlamydomonas sp.																							
Euglena sp.																							
Trypotomonas sp.																							
Mallomonas sp.																							
Chrysococcus sp.																							
Trachelomonas sp.																							
Centric Diatoms																							
Cyclotella sp.																							
Melosira sp.																							

Water Quality Laboratory, Indiana and Grand Lake, Ohio

Sampling Date and Station No. / Algae - Number ml	
Centric Diatoms	
Stephanodiscus sp.	
Cyclotella sp.	
Melosira sp.	
Unidentified sp.	
Pennate Diatoms	
Fragilaria sp.	
Synedra sp.	
Asterionella sp.	
Tabellaria sp.	
Diatomella sp.	
Total	

• No sample taken.

Phytoplankton Data

Table 27

Sheet 1 of Table 27

Wabash River, Indiana and Grand Lake, Ohio

Sampling Date and Station No.																		
Algae - Number/ml																		
Coccoid Blue-Green Algae																		
Anacystis sp.																		
Agmenellum sp.																		
Coelosphaerium sp.																		
Filamentous Blue-Green Algae																		
Schizothrix calcicola																		
Aphanizomenon sp.																		
Coccoid Green Algae																		
Scenedesmus sp.																		
Selenastrum sp.																		
Tetraedron sp.																		
Coelastrum sp.																		
Ankistrodesmus sp.																		
Pediastrum sp.																		
Tetrastrum sp.																		
Dictyosphaerium sp.																		
Micractinium sp.																		
Oocystis sp.																		
Schroederia sp.																		
Lagerheimia sp.																		
Crucigenia sp.																		
Actinastrum sp.																		
Chlorella sp.																		
Desmids																		
Staurastrum sp.																		
Closterium sp.																		
Flagellates																		
Chlamydomonas sp.																		
Conium sp.																		
Euglena sp.																		
Cryptomonas sp.																		
Phacus sp.																		
Chrysococcus sp.																		
Mallomonas sp.																		
Trachelomonas sp.																		
Synura sp.																		
Peridinium sp.																		
Dinobryon sp.																		
Centric Diatoms																		
Cyclotella sp.																		
Melosira sp.																		

12. Explanation Data

Wabash River, Indiana and Grand Lake, Ohio

Sampling Date and Station No. / Algae - Number ml	Mar 1	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar
Pennate Diatoms																				
Nitzschia sp.																				
Synedra sp.																				
Navicula sp.																				
Gomphonema sp.																				
Surirella sp.																				
Diatoma sp.																				
Cymbella sp.																				
Asterionella sp.																				
Total																				

Phytoplankton Data

Wabash River, Indiana and Great Lake, Ohio

Sampling Date and Station No. / Algae - Number ml																				
Coccoid Blue-Green Algae																				
Anacystis sp.	1,200																			
Coelosphaerium sp.	400																			
Filamentous Blue-Green Algae																				
Schizothrix calcicola	140,000																			
Aphanizomenon sp.	1,400																			
Coccoid Green Algae																				
Scenedesmus sp.	1,000																			
Pediastrum sp.	80																			
Actinastrum sp.	1,400																			
Dictyosphaerium sp.	200																			
Coelastrum sp.	200																			
Oocystis sp.	80																			
Tetrastrum sp.	800																			
Golenkinia sp.	200																			
Chlorella sp.	200																			
Micractinium sp.																				
Ankistrodesmus sp.																				
Desmids																				
Staurastrum sp.	40																			
Flagellates																				
Chlamydomonas sp.	800																			
Cryptomonas sp.	200																			
Chrysococcus sp.																				
Mallomonas sp.																				
Euglena sp.																				
Peridinium sp.																				
Dinobryon sp.																				
Trachelomonas sp.																				
Centric Diatoms																				
Cyclotella sp.																				
Melosira sp.	400																			
Pennate Diatoms																				
Nitzschia sp.	1,800																			
Synedra sp.	2,000																			
Navicula sp.																				
Gomphonema sp.																				
Surirella sp.																				
Hantzschia sp.																				
Asterionella sp.																				
Diatoma sp.																				
Cocconeis sp.																				
Pholcosphaenia curvata																				

Phytoplankton Data

Wabash River, Indiana and Grand Lake, Ohio

Part 2 of Table P3

Sampling Date and Station No. / Algae - Number ml	Mar 20 W-101	Mar 20 W-102	Mar 20 W-103	Mar 20 W-104	Mar 20 W-105	Mar 20 W-106	Mar 20 W-107	Mar 20 W-108	Mar 20 W-109	Mar 20 W-110	Mar 20 W-111	Mar 20 W-112	Mar 20 W-113	Mar 20 W-114	Mar 20 W-115	Mar 20 W-116	Mar 20 W-117	Mar 20 W-118	Mar 20 W-119	Mar 20 W-120
Pennate Diatoms (Cont'd)																				
Fragilaria sp.																				
Cymbella sp.																				
Meridian sp.																				
Total																				

Phytoplankton Data

Wabash River, Indiana and [illegible]

Sampling Date and Station No. / Algae - Number /	[illegible]
Coccoid Blue-Green Algae	
Anacystis sp.	
Aphanocapsa sp.	
Coccochloris sp.	
Filamentous Blue-Green Algae	
Schizothrix calcicola	
Aphanizomenon sp.	
Oscillatoria sp.	
Coccoid Green Algae	
Coenocystis sp.	
Tetraedron sp.	
Coelastrum sp.	
Ankistrodesmus sp.	
Pediastrum sp.	
Tetrastrum sp.	
Platysphaerium sp.	
Micractinium sp.	
Oocystis sp.	
Schroederia sp.	
Lagerheimia sp.	
Actinastrum sp.	
Golenkinia sp.	
Crucigenia sp.	
Chlorella sp.	
Desmids	
Staurastrum sp.	
Closterium sp.	
Flagellates	
Chlamydomonas sp.	
Euglena sp.	
Cryptomonas sp.	
Chrysococcus sp.	
Dinobryon sp.	
Mallomonas sp.	
Eudorina sp.	
Synura sp.	
Trachelomonas sp.	
Centric Diatoms	
Cyclotella sp.	
Melosira sp.	

Phytoplankton Data

Wabash River, Indiana and Great Lake, 1973

Sampling Date and Station No Algae - Number ml	Apr 11 W-101	Apr 11 W-102	Apr 17 W-103	Apr 17 W-104	Apr 17 W-105	Apr 11 W-1	Apr 11 W-2	Apr 11 W-3	Apr 11 W-4	Apr 11 W-71	Apr 11 W-72	Apr 10 W-73	Apr 10 W-1	Apr 17 W-2	Apr 10 W-3	Apr 17 W-4	Apr 10 W-5*
Pennate Diatoms																	
Nitzschia sp.	1,125																
Cymbella sp.	11,700																
Surirella sp.		114															
Gomphonema sp.			114														
Pyrosigma sp.																	
Navicula sp.		228															
Rhicosphenia curvata																	
Hantzschia sp.																	
Asterionella sp.																	
Cymatopleura solea																	
Cymbella sp.																	
Diatoma sp.																	
Total	100,913	14,962	1,141														

* No sample taken.

Phytoplankton Data — Table 25 — Page 1 of Table 25

Wabash River, Indiana and Grand Lake, Ohio

Sampling Date and Station No. Algae - Number/ml	Mar. 7 W-101	Mar. 8 W-107	Mar. 8 W-102	Mar. 7 W-101	Mar. 7 W-1	Mar. 7 W-101	Mar. 7 W-102	Mar. 7 W-107	Mar. 7 W-22	Mar. 7 W-45	Mar. 7 W-53	May 7 W-70	Mar. 7 W-71	Mar. 7 W-41	Mar. 10 W-42	Mar. 10 W-33	Mar. 11 W-31	Mar. 11 W-32
Coccoid Blue-Green Algae																		
Anacystis sp.	7,417																	
Lemphosphaeria sp.	501																	
Filamentous Blue-Green Algae																		
Schizothrix calcicola	101,01	84						501	1,077	987	672	384	1,830	372	1,374	501	228
Aphanizomenon sp.	399																	
Coccoid Green Algae																		
Scenedesmus sp.	3,906	900	171	294		342	342	456	1,026	1,026	1,773	1,144	2,974	2,632	3,260	8,424	1,779	1,940
Selenastrum sp.			57			171			798	29	257			57			143	29
Tetraedron sp.	114									172	57			57				29
Micractinium sp.	456		142	429	285	171	684	570	969	627	798	114	684	684	1,317	3,718	969	969
Lagerheimia sp.	86									29			57			343		29
Coelastrum sp.	430				86		43	172	43				43	229	43	686	29	
Schroederia sp.	114																	
Dactylis sp.	43												143	114	43	429	257	543
Dictyosphaerium sp.	1,174			86	143	86	86	57	114	443	457	114	515	286	343	1,288	57	172
Pediastrum sp.	43			57	29	29				29				29		57	57	
Actinastrum sp.	487	171	86	500	81	457	2,974	943	457	443	829	229	715		1,600	8,150	1,887	1,489
Tetrastrum sp.	2,052	29			458		86	172	86	172	57	57	257	172	229	2,373	114	114
Ankistrodesmus sp.			114	401	1,201	114	314	543	401	429	286	458	401	443	1,202	429	257	
Golenkinia sp.				57								29	29			114		
Chlorella sp.																172	34	
Crucigenia sp.									114									
Coelosphaerium sp.											57						257	
Desmids																		
Staurastrum sp	57															29		
Closterium sp.	29			29		29				29				57		29		
Flagellates																		
Chlamydomonas sp.	172	29	114	200	114	8		8	430	400	572	229	143	401	286		343	
Euglena sp.	700	572	86	57	257	172	172	343	86	258	286	57	229	515	57	458	57	86
Trachelomonas sp.	57		29					29							29			57
Cryptomonas sp.				57	257	57		57	429	257	458	629	572				57	57
Chrysococcus sp.			86	458	515	200	143	458	515	515	343		114		114	458	343	86
Pascheriella sp.									29		29							
Dinobryon sp.				114						172								
Pandorina sp.																	29	
Mallomonas sp.				29														
Centric Diatoms																		
Cyclotella sp.	200	729	11,308	12,134	18,914	28,479	42,8#	15,700	53,997	54,415	64,927	40,412	33,805	32,030	13,334	35,621	*	4,737
Melosira sp.	229			943	172		86			200	143	57		257	86	372	5,655	429

Phytoplankton Data

Table 25 (Cont'd)
May 1967

Wabash River, Indiana and Grant Lake, Ohio

Sampling Date and Station No Algae - Number/ml	May 4 W-121	May 4 W-197	May 6 W-155	May 7 W-151	May 7 W-140	May 7 W-137	May 7 W-129	May 7 W-117	May 7 W-99	May 7 W-93	May 7 W-85	May 7 W-79	May 7 W-71	May 9 W-61	May 10 W-4	May 10 W-33	May 10 W-14	May 10 W-10
Pennate Diatoms																		
Nitzschia sp.	931	1,171	530	200	1,058	1,244	1,444	1,037	2,574	2,460	2,431	3,088	2,145	1,843	1,631	2,774	415	572
Synedra sp.	4,367	29	86	400	1,330	1,631	1,172	754	1,201	772	1,032	987	1,659	1,430	1,373	7,322	1,829	1,258
Navicula sp.						57		57	172	114			57		114	143		
Asterionella sp.							172		343	1,201	772	229	688	343	515	2,345	1,445	2,632
Cocconeis sp.									29								29	
Diatoma sp.										29								
Amphonema sp.		57									29		57					
Cymbella sp.								57			58		172		57		29	
Surirella sp.			29										29		114			
Total	105,213	1,457	14,016	17,758	25,317	27,044	50,803	24,119	43,150	47,775	57,490	40,744	40,346	43,119	31,346	75,077	17,752	16,308

Phytoplankton Data

Table 25
June 1968

Wabash River, Indiana and Grand Lake, Ohio

Sampling Data and Station No. Algae - Number/ml	June 12 W-161	June 12 W-157	June 12 W-155	June 12 W-151	June 12 W-146	June 11 W-133	June 11 W-129	June 11 W-117	June 11 W-99	June 11 W-95	June 11 W-89	June 11 W-79	June 11 W-71	June 11 W-61	June 10 W-45	June 10 W-33	June 12 W-19	June 12 W-10
Coccoid Blue-Green Algae																		
Anacystis sp.	1,[illegible]80	2,349	464	174	116			[illegible]										
Gomphosphaeria sp.	[illegible]58	58																
Agmenellum sp.	116																	
Filamentous Blue-Green Algae																		
Schizothrix calcicola	370,788	109,260	2,194	4,756	348	522	[illegible]	464	[illegible]	580	348	[illegible]	[illegible]	406	174	174		
Aphanizomenon sp.	4,314	1,972		145		348	928		348	232	174	348		29				
Oscillatoria sp.	349	58		58							116							
Coccoid Green Algae																		
Scenedesmus sp.	1,512	464	580	580	1,044	2,320	1,972	[illegible]	3,132	2,088	1,508	928	638	609	174	464	290	174
Pediastrum sp.	116			116	[illegible]	116	[illegible]	58			58			58				
Oocystis sp.	116						261	116	232	116	870				29		174	
Dictyosphaerium sp.	174		58	261	725	116	[illegible]	464	261	174	348							
Actinastrum sp.	58		609	638	1,218	696	1,363	1,421	1,102	812	609	116	58	58		522		
Golenkinia sp.	58						116											
Tetrastrum sp.	5		377	232	58	174		464	812	261	290			58				
Chlorella sp.	350																58	
Tetraedron sp.	58	116			29		232											
Ankistrodesmus sp.	58	232	348	928		464	435	812	348	[illegible]	290	116	58	174	58	116	58	
Lagerheima sp.	58		29	116	116	58	406	232			87	58						
Selenastrum sp.			116				348				174					29		
Coelastrum sp.			116	87		58	116	[illegible]	[illegible]	232			58					
Micractinium sp.			87	87	116		116	232		261	174	116		87			58	58
Crucigenia sp.										580								
Treubaria sp.											116							
Kirchneriella sp.			145															
Schroederia sp.					58	174												
Desmids																		
Staurastrum sp.	58																	
Closterium sp.				58	58	174		29	58	203				29				
Flagellates																		
Chlamydomonas sp.	116	1,044	1,856	812	1,624	2,842	3,712	[illegible]	2,842	3,480	[illegible]	2,552	1,305	377	232	406	638	348
Euglena sp.	232	232	116	232	348	928	348	609	87	174	232	116	58	348	580	87	232	29
Cryptomonas sp.	348		116	261	928	232	261	145		116			58					
Trachelomonas sp.			174	174		58	58		58								58	145
Carteria sp.													116					
Gonium sp.								29				29						
Mallomonas sp.			29					348										
Chrysococcus sp.	58		261	116	464			1,044	58	464	522	174		29	116	145	58	
Centric Diatoms																		
Cyclotella sp.		58	12,064	4,988	27,840	14,152	47,850	42,456	16,240	15,820	20,950	16,240	2,088	2,842	928	957	1,044	725
Melosira sp.	232	116	2,378	3,509	3,712	4,640	16,240	10,672	8,352	15,312	23,200	25,404	26,332	24,766	21,634	8,236	696	667